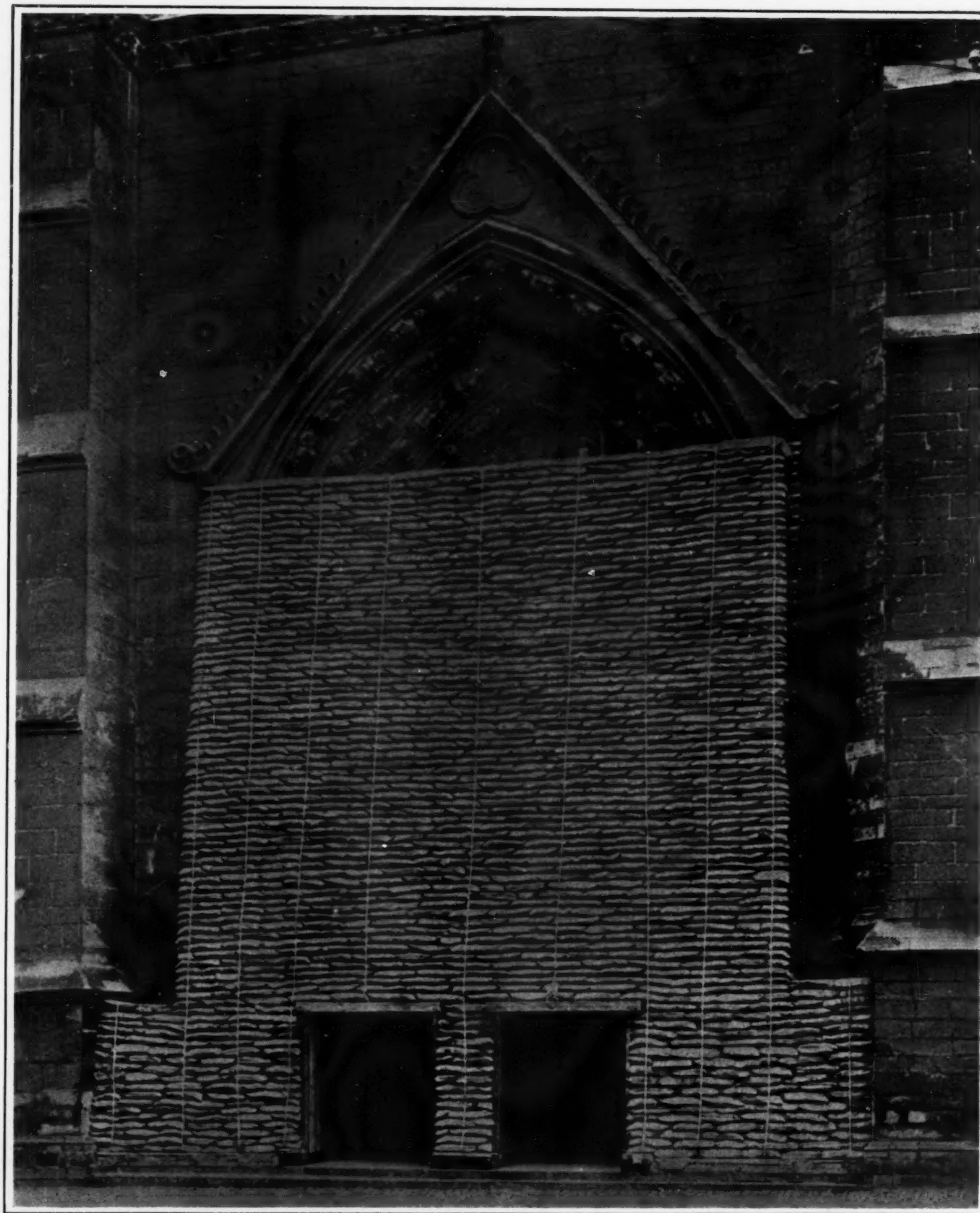
SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXXI
NUMBER 2091

★ NEW YORK, JANUARY 29, 1916 ★

10 CENTS A COPY
$5.00 A YEAR



A sand-bag shield before the Cathedral at Amiens, to protect its elaborate carvings from gunfire.

THE DESTRUCTION OF HISTORICAL EDIFICES IN EUROPE.—[See page 68.]

The Construction of the Heavens*

A Survey of Progress of Sidereal Astronomy

Our knowledge of the fixed stars, as they were called by the old astronomers, is of comparatively recent origin, and is derived from two sources: (1) the measurement of small changes in the positions of the stars in the sky, and (2) the analysis of the light received from them and the measurement of its amount. To this end the numerous instruments of a modern observatory have been devised. The desire to examine fainter objects, and still more the necessity of increasing the accuracy of observations, has brought about a continuous improvement in the range and accuracy of astronomical instruments. Methods which had been perfected for observations of a few stars have been extended so that they can be applied to a large number. For these reasons the progress of sidereal astronomy may seem to have gone on slowly for a time. The more rapid progress of recent years arises from the accumulation of data, for which we are indebted to generations of astronomers, and from the gradual increase in power and perfection of our instruments.

The first insight into the stars as a whole naturally came from the survey of their numbers and distribution; and Herschel, who constructed the first great telescopes, explored the heavens with untiring skill and energy, and speculated boldly on his observations, is justly regarded as the founder of sidereal astronomy. In his great paper "On the Construction of the Heavens," Herschel gives the rules by which he was guided, which I should like to quote, as they may well serve as a motto to all who are engaged in the observational sciences:

"But first let me mention that if we would hope to make any progress in an investigation of this delicate nature we ought to avoid two opposite extremes of which I can hardly say which is the most dangerous. If we indulge a fanciful imagination and build worlds of our own, we must not wonder at our going wide from the path of truth and nature; but these will vanish like the Cartesian vortices, that soon gave way when better theories were offered. On the other hand, if we add observation to observation, without attempting to draw not only certain conclusions but also conjectural views from them, we offend against the very end for which only observations ought to be made. I will endeavor to keep a proper medium; but if I should deviate from that I could wish not to fall into the latter error." In this spirit he discussed the "star gages" or counts of stars visible with his great reflector in different parts of the sky, and concluded from them that the stars form a cluster which stretches to an unknown but finite distance, considerably greater in the plane of the Milky Way than in the perpendicular direction. He gave this distance as 497 times that of Sirius. He did not hesitate to advance the theory that some of the nebulæ were similar clusters of stars, of which that in Andromeda, judging from its size, was the nearest. Herschel had no means of telling the scale of the sidereal system, though he probably supposed the parallax of Sirius to be of the order of 1 second.

Though some of the assumptions made by Herschel are open to criticism, the result at which he arrived is correct in its general outline. I shall attempt to give a brief account of some of the principal methods used to obtain more definite knowledge of the extent and constitution of this "island universe." The stars of which most is known are, in general, those nearest to us. If the distance of a star has been measured, its co-ordinates, velocity perpendicular to the line of sight, and luminosity are easily found. In the case of a double star the orbit of which is known the mass may also be determined. But only a very small proportion of the stars are sufficiently near for the distance to be determinable with any accuracy. Taking the distance corresponding to a parallax of 1 second or the parsec as unit, i. e., 200,000 times the distance of the earth from the sun, fairly accurate determinations can be made up to a distance of 25 parsecs, but only rough ones for greater distances.

For much greater distances satisfactory average results are obtainable from proper motions, and the mean distances of particular classes of stars—for instance, stars of a given magnitude or given type of spectrum—can be found with considerable confidence up to a distance of 500 parsecs, and with considerable uncertainty to twice this distance. The density of stars in space as a function of the distance, the percentage of stars within different limits of luminosity, the general trend of the movement of stars and their average velocities can also be found, within the same limits of distance.

For all distances, provided the star is sufficiently bright, its velocity to or from the earth can be measured. The general consideration of these velocities supplies complementary data which cannot be obtained from proper motions, and confirms other results obtained by their means. For distances greater than 1,000 parsecs our knowledge is generally very vague. We have to rely on what can be learned from the amount and color of the light of the stars, and from their numbers in different parts of the sky.

Let us begin with the portion of space nearest to us, within which the parallaxes of stars are determinable. The successful determination of stellar parallax by Bessel, Struve, and Henderson in 1838 was a landmark in sidereal astronomy. The distances of three separate stars were successfully measured, and for the first time the sounding line which astronomers had for centuries been throwing into space touched bottom. The employment of the heliometer which Bessel introduced was the main source of our knowledge of the distance of stars until the end of the nineteenth century, and resulted in fairly satisfactory determination of the parallaxes of nearly one hundred stars. For the part of space nearest to us this survey is sufficiently complete for us to infer the average distances of the stars from one another—2½ to 3 parsecs. The parallax determinations of double stars of known orbits lead to the result that the masses of stars have not a very great range, but lie between forty times and one tenth of the mass of the sun.

When the absolute luminosities of the stars the distances of which have been measured are calculated, it is found that, unlike the masses, they exhibit a very great range. For example, Sirius radiates forty-eight times as much light as the sun, and Groombridge 34 only one-hundredth part. This does not represent anything like the complete range, and Canopus, for example, may be ten thousand times as luminous as the sun. But among the stars near the solar system, the absolute luminosity appears to vary with the type of spectrum. Thus Sirius, of type A, a blue hydrogen star, is forty-eight times as luminous as the sun; Procyon of type F5—bluer than the sun, but not so blue as Sirius—ten times; α Centauri, which is nearly of solar type, is twice as luminous. 61 Cygni of type K5—redder than the sun—one tenth as luminous; while the still redder star of type Ma, Gr 34, is only one-hundredth as luminous. In the neighborhood of the solar system one third of the stars are more luminous and two thirds less luminous than the sun. The luminosity decreases as the type of spectrum changes from A to M, i. e., from the blue stars to the red stars.

These three results as to the density in space, the mass, and the luminosity have been derived from a very small number of stars. They show the great value of accurate determinations of stellar parallax. So soon as the parallax is known, all the other observational data are immediately utilizable. At the commencement of the present century the parallaxes of perhaps eighty stars were known with tolerable accuracy. Happily the number is now rapidly increasing by the use of photographic methods. Within the last year or two, the parallaxes of nearly two hundred stars have been determined and published.

The determination of radial velocities was initiated by Huggins in the early 'sixties, but trustworthy results were not obtained until photographic methods were introduced by Vogel in 1890. Since that time further increase in accuracy has been made, and the velocity of a bright star with sharp lines is determinable (apart from a systematic error not wholly explained) with an accuracy of ¼ kilometer per second. As the average velocities of these stars are between 10 and 20 kilometers a second, the proportional accuracy is of a higher order than can be generally obtained in parallax determinations or in other data of sidereal astronomy. A number of observatories in the United States and Europe, as well as in South America, the Cape, and Canada, are engaged in this work. Especially at the Lick Observatory under Prof. Campbell's direction, the combination of a large telescope, a well-designed spectroscope, and excellent climatic conditions has been utilized to carry out a bold programme. At that observatory, with an offshoot at Cerro San Cristobal in Chile, for the observations of stars in the southern hemisphere, the velocities of 1,200 of the brightest stars in the sky have been determined. Among the results achieved is a determination of the direction and amount of the solar motion. The direction serves to confirm the results from proper motions, but the velocity is only obtainable accurately by this method. This quantity, which enters as a fundamental constant in nearly all researches dealing with proper motion, is given by Campbell at 19.5 kilometers per second, or 4.1 times the distance of the earth from the sun per annum, though there is some uncertainty arising from a systematic error of unknown origin.

The observations of radial velocities have shown within what limits the velocities of stars lie and have given a general idea of their distribution. The most important result, and one of a somewhat surprising character, is that the mean velocities of stars, the motion of the sun being abstracted, increase with the type of spectrum. Thus, the stars of type B, the helium stars, the stars of the highest temperature, have average radial velocities of only 6.5 kilometers per second; the hydrogen stars of type A have average velocities of 11 kilometers per second; the solar stars, of 15 kilometers per second; while for red stars of type K and M it has increased slightly more to 17 kilometers per second. Further, the few planetary nebulæ, i. e., condensed nebulæ with bright line spectra, have average velocities of 25 kilometers per second. There can be no question of the substantial accuracy of these results, as they are closely confirmed by discussions of proper motions. They are however very difficult to understand. On the face of it, there does not seem any reason why stars of a high temperature should have especially high velocities. A suggestion has been thrown out by Dr. Halm that as the helium stars have greater masses, these results are in accordance with an equi-partition of energy. But the distances of stars apart is so great that it seems impossible that this could be brought about by their interaction. Prof. Eddington suggests that the velocities may be an indication of the part of space at which the stars were formed (e. g., stars of small mass in outlying portions), and represents the kinetic energy they have acquired in arriving at their present positions.

The stars the radial velocities of which have been determined are, generally speaking, brighter than the fifth magnitude. Fainter stars are now being observed. At the Mount Wilson Observatory, Prof. Adams has determined the velocities of stars of known parallaxes, as there are great advantages in obtaining complete data for stars where possible.

As proper motions are determined by the comparison of the positions of stars at two different epochs, they get to be known with constantly increasing accuracy as the time interval increases. The stars visible to the naked eye in the northern hemisphere were accurately observed by Bradley in 1755. Many thousands of observations of faint stars down to about 9.0 magnitude were made in the first half of the nineteenth century. An extensive scheme of re-observation was carried out about 1875 under the auspices of the Astronomische Gesellschaft. A great deal of re-observation of stars brighter than the ninth magnitude has been made this century in connection with the photographic survey of the heavens. For the bright stars all available material has been utilized and their proper motions have been well determined, and for the fainter stars this is being gradually accomplished.

Proper motions differ widely and irregularly in amount and direction. Herschel observed a tendency of a few stars to move toward one point of the sky, and attributed this sign of regularity to a movement of the solar system in the opposite direction. But puzzling differences given by different methods remained unexplained until the difficulty was resolved by Prof. Kapteyn in a paper read before this section of the British Association at its meeting in South Africa ten years ago. He showed that the proper motions had a general tendency toward two different points of the sky and not toward one only, as would be expected if the motions of the stars themselves were haphazard, but viewed from a point in rapid motion. He concluded from this that there was a general tendency of the stars to stream in two opposite directions. It is interesting to notice that this great discovery was made by a simple graphical examination of the proper motions of stars in different regions of the sky, after the author had spent much time in examining and criticising the different methods which had been adopted for the determination of the direction of the solar motion. The subject was brought into a clearer and more exact shape by the analytical formulation given to it by Prof. Eddington, and after him by Prof. Schwarzschild.

This star-streaming is corroborated by observations of velocities in the line of sight. It applies, with the exception of the helium stars, to all stars which are

* From the opening address by Sir F. W. Dyson, M.A., LL.D., F.R.S., president of the Section of Mathematics and Physics of the British Association for the Advancement of Science.

near enough for their proper motions to be determinable. We may say with certainty that it extends to stars at distances of two or three hundred parsecs; it may extend much farther, but I do not think we have at present much evidence of this. Prof. Turner pointed out that the convergence of proper motions did not necessarily imply movements in parallel directions, and suggested that the star-streams were movements of stars to and from a center. The agreement of the radial velocities with the proper motions seems to me to be opposed to this suggestion, and to show that star-streaming indicates approximate parallelism in two opposite directions in the motions of the stars examined. As the great majority of these stars are comparatively near to us, it is possible that this parallelism is mainly confined to them, and indicates the general directions of the orbital motions of stars in the neighborhood. An attempted explanation on these lines, as on Prof. Turner's, implies that the sun is some distance from the center of the stellar system.

A discovery of an entirely different character was made by Prof. Boss in 1908. He spent many years in constructing a great catalogue giving the most accurate positions and motions of 6,200 stars obtainable from all existing observations. This catalogue, which was published by the Carnegie Institution, was intended as a preliminary to a still larger one which would give the accurate positions and motions of all the stars down to the seventh magnitude. In the course of this work Prof. Boss found that forty or fifty stars scattered over a considerable region of the sky near the constellation Taurus were all moving toward the same point in the sky and with nearly the same angular velocity. He inferred that these stars were all moving in parallel directions with an equal linear velocity, and the supposition was verified in the case of several of them, by the determination of their radial velocities. From these data he was able to derive the distance of each star and thus its position in space. The existence of a large group of stars, separated from one another by great distances, and all having the same motion in space, is a very remarkable phenomenon. It shows, as was pointed out by Prof. Eddington, how small is the gravitational action of one star on another, and that the movement of each star is determined by the total attraction of the whole mass of the stars. Several other interesting moving clusters have been found since. For all the stars belonging to these clusters, the distances have been found, and from them luminosities and velocities of individual stars, particulars which are generally only obtainable for stars much nearer to us.

Proper motions are the main source of our knowledge of the distances of stars which are beyond the reach of determination by annual parallax. If a star were known to be at rest its distance could be calculated from the shift of its apparent position caused by the translation of the solar motion. As the solar system moves 410 times the distance of the earth from the sun in a century, this gives a displacement of 1 second for a star at the distance of 500 parsecs. This method has been applied by Kapteyn to determine the distances of the helium stars, as their velocities are sufficiently small to be neglected in comparison with that of the solar system. But generally it is only possible to find the mean distances of groups of stars of such size that it may be assumed that the peculiar motions neutralize one another in the mean.

In conjunction with another observational law which expresses the number of stars as a function of the magnitude, this leads to a determination of the density of stars in space at different distances from us, and also of the "luminosity law," i. e., the percentage of stars of different absolute brightness. Profs. Seeliger and Kapteyn have shown in this way that there is a considerable falling off of star-density as we go farther from the solar system. It seems to me very necessary that this should be investigated in greater detail for different parts of the sky separately. A general mathematical solution of general questions which arise in the treatment of astronomical statistics has been given by Prof. Schwarzschild. His investigations are of the greatest value in showing the exact dependence of the density, luminosity, and velocity laws on the statistical facts which can be collected from observation. The many interesting statistical studies which have been made are liable to be rather bewildering without the guidance furnished by a general mathematical survey of the whole position.

When the proper motions are considered in relation to the spectral types of the stars, the small average velocities of the hydrogen stars and still smaller ones of the helium stars found from line-of-sight observations are confirmed. If stars up to a definite limit of apparent magnitude, say, to 6.0 magnitude, or between certain limits, say 8.0 magnitude and 9.0 magnitude, are considered, then the solar stars are found to be much nearer than either the red or the blue stars. Thus both red and blue stars must be of greater intrinsic luminosity than the solar stars. As regards blue stars, this agrees with results given by parallax observations. But the red stars appear to consist of two classes, one of great and one of feeble luminosity, and it does not seem that a sufficient explanation is given by the fact that a selection of stars brighter than any given apparent magnitude will include the very luminous stars which are at a great distance, but only such stars of feeble luminosity as are very near.

The significance of these facts was pointed out by Prof. Hertzsprung and Prof. Russell. They have a very important bearing on the question of stellar evolution, a subject for discussion at a meeting held later. From the geometrical point of view of my address these facts are of importance in that they help to classify the extraordinarily large range found in the luminosities of stars. Putting the matter somewhat broadly, the A stars, or hydrogen stars, are on the average intrinsically five magnitudes brighter than the sun, while the range in their magnitude is such that half of them are within three quarters magnitude of the mean value. The stars of type M, very red stars, are of two classes. Some of them are as luminous as the A stars and have a similar range from about a mean value five magnitudes brighter than the sun. Others, on the contrary, have a mean intrinsic brightness five magnitudes fainter than the sun and with the same probable deviation of three quarters magnitude. Between the types M and A there are two classes the distance apart of which diminishes as the stars become bluer. The facts in support of this contention were very forcibly presented by Prof. Russell in *Nature* in May, 1914. If this hypothesis is true, and it seems to me there is much to be said in its favor, then the apparent magnitude combined with the type of spectrum will give a very fair approximation to the distances of stars which are too far away for their proper motions to be determinable with accuracy.

In dealing with the proper motions of the brighter stars, the sky has been considered as a whole. Now that the direction and amount of the solar motion are known, we may hope that, as more proper motions become available, the different parts of the sky will be studied separately. In this way we shall obtain more detailed knowledge of the streaming, and also of the mean distances of stars of different magnitudes in all parts of the sky, leading to a determination of how the density of stars in space changes in different directions. A second line of research which may be expected to give important results is in the relationship of proper motions to spectral type. There is in preparation at Harvard College by Miss Cannon, under Prof. Pickering's direction, a catalogue giving the type of spectrum of every star brighter than the ninth magnitude. It would be very desirable to determine the proper motions of all these stars. If all the material available is examined it should be possible to do this to a very large extent.

For the more distant parts of the heavens proper motions are an uncertain guide, and we must depend on what can be learned from the light of the stars by means of stellar photometry, determinations of color, and studies of stellar spectra. Speaking generally, we attempt to discover from the nearer stars sufficient about their intrinsic luminosities to enable us to use the apparent magnitude as an index of the distances of the stars which are farther away. The most striking example is found in Prof. Hertzsprung's determination of the distance of the small Magellanic cloud. From a knowledge of the characteristics of the Cepheid variables found in this cloud by Miss Leavitt, and their apparent magnitude, he deduced the distance of the cloud as 10,000 parsecs.

Much attention has been given of late years to stellar photometry. In 1899 Prof. Pickering published the Revised Harvard Photometry giving the magnitudes of all stars brighter than 6.5 magnitudes. In 1907 Messrs. Müller and Kempf completed a determination of 14,199 stars of the northern hemisphere brighter than 7.5 magnitude. In 1908 a catalogue of 36,682 stars fainter than 6.5 magnitude was published at Harvard. These determinations derive additional importance as they give the means of standardizing estimates of magnitude made by eye, particularly the many thousands of the Bonn Durchmusterung.

By the labors of Prof. Pickering and his colleagues at Harvard, Prof. Schwarzschild, Prof. Parkhurst at Yerkes, Prof. Seares at Mount Wilson, and others, the determination of the magnitudes of stars by photography has made rapid strides. As yet no complete catalogues of photographic magnitude corresponding to the Revised Harvard Photometry have been published, though considerable parts of the sky and special areas, such as the Pleiades, have been carefully studied. The determination of the photographic magnitudes of any stars which may be required is, however, a comparatively simple matter when the magnitudes of sufficient standard stars have been found. A trustworthy and uniform scale has been to a large extent secured by the use of extra-focal images, gratings, and screens in front of the object glass, and the study of the effects of different apertures and different times of exposure.

At Harvard and Mount Wilson, standard magnitudes of stars near the north pole have been published extending to nearly the twentieth magnitude. In the part of the range extending from 10.0 magnitude to 16.0 magnitude these agree very satisfactorily. There is, however, a difference of 0.4 magnitude in the scale between 6.0 magnitude and 10.0 magnitude which needs to be cleared up.

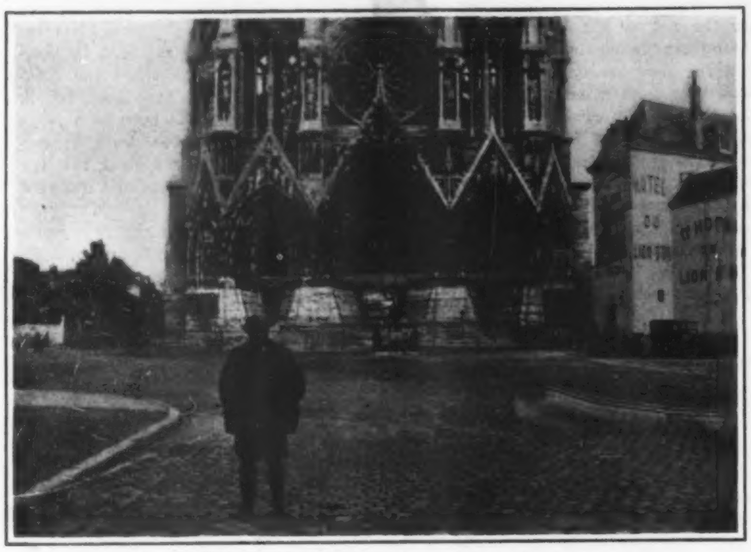
A uniform and accurate scale of magnitude is of fundamental importance in counts of the numbers of stars. Such counts aim at the determination of two things: (1) how the numbers vary in different parts of the sky, and (2) what is the ratio of the number of stars of each magnitude to that of the preceding magnitude in the same area of the sky. The counts of stars from the gages of Sir William and Sir John Herschel, those of the stars contained in the Bonn Durchmusterung, those made by Prof. Celoria, and the recent counts of the Franklin-Adams plates by Dr. Chapman and Mr. Melotte, all agree in showing a continuous increase of stars as we proceed from the pole of the galaxy to the galaxy itself. The importance of this fact is that it shows a close connection between the Milky Way and the stars nearer to us.

Photometric observations have acquired additional importance from the differences between photographic and visual magnitudes. The ordinary plate is more sensitive to blue light than the eye, and the difference between the photographic and visual (or photo-visual) magnitude of a star is an index of the color. The color index is found by observation to be related very closely to the type of spectrum. Prof. Seares has shown from the color indices that as the stars become fainter they become progressively redder. Prof. Hertzsprung has found the same thing by the use of a grating in front of the object glass. Among stars of 17.0 visual magnitude, Sears found none with a color index less than 0.7; this is approximately the color index of a star of solar type, i. e., near the middle of the range from blue stars to red stars.

There are three ways in which this may occur. The stars may be bright but very distant red stars; or they may be faint red stars, like those in the immediate neighborhood of the sun; or there may have been an absorption of blue light. It is not possible to say in what proportion these causes have contributed. The red stars of 9.0 magnitude and 10.0 magnitude are nearly all very luminous but distant bodies, but it seems likely that stars of 17.0 magnitude will contain a greater proportion of stars of small luminosity.

The absorption of light in space is very small, and as yet imperfectly determined. Prof. Kapteyn and Mr. Jones, by comparing the color indices of stars of large and small proper motion, make the difference between the absorption of photographic and visual light as 1 magnitude in 2,000 parsecs. The question has been examined directly by Prof. Adams, who has obtained spectra of near and distant stars which are identical as regards their lines, and has examined the distribution of the continuous light. This direct method of comparison showed that the more distant star was always weaker in violet light. But as both these investigations show that very luminous stars are intrinsically somewhat bluer than less luminous stars of the same spectral type, the two causes require further research for their disentanglement. The question is of importance, as it may serve in some cases to determine the distances of very remote bodies the type of spectrum of which is known.

It must be admitted that we are as yet very ignorant of the more distant parts of the "island universe." For example, we can make little more than guesses at the distance of the Milky Way, or say what part is nearest to us, what are its movements, and so on. But, nevertheless, the whole subject of the construction of the heavens has been opened up in a remarkable manner in the last few years. The methods now employed seem competent to produce a tolerably good model showing the co-ordinates and velocities of the stars as well as their effective temperatures and the amount of light they radiate. Industry in the collection of accurate data is required, along with constant attempts to interpret them as they are collected. The more accurate and detailed our knowledge of the stellar system as it is now, the better will be our position for the dynamical and physical study of its history and evolution.



Front of the Cathedral at Rheims with protecting screens.

A closer view of the screens at the Cathedral at Rheims.

The Destruction of Historic Edifices in Europe

And Efforts Made for Their Protection

Long after the present gigantic struggle in Europe has passed into history there will remain one lasting record as a memorial of Teutonic methods and a constant reminder of the savage assault that this nation has deliberately and systematically made on civilization. This record is indelibly written on the ruins of the noble cathedrals and public buildings, at Rheims, Louvain, Arras, Amiens, Ypres and many other places in Belgium and in France, where utterly wanton and unnecessary destruction has been so recklessly wrought. That Germany will in time to come seriously regret this lasting record of her barbarism there can be no doubt.

That the destruction of these priceless specimens of the art of the architect, the sculptor and the builder was intentional and a demonstration of resentment and revenge is shown by the conditions existing in practically every instance. In Rheims the city as a whole suffered comparatively little damage, according to the reports of civilians who have visited that city within the last few months; but the destruction which was confined to the magnificent cathedral and its immediate vicinity clearly shows that this was the target of the German gunners, for there were no fortifications nor bodies of troops in the city to make a bombardment necessary. Ypres affords another example of these methods and purposes, for at the time of the bombardment that destroyed its famous Cloth Hall the forces of the Allies were five miles in advance of that city. In most cases the shelling of the cities was continued at intervals long after such practices had been denied at Berlin.

In many cases the destruction of these targets of German spite has been complete, although in some instances much that is of value remains. The walls and towers of the magnificent cathedral at Rheims still stand, although badly scarred, and great quantities of the beautiful carving is defaced. The outer roof is gone, and nothing of the non-structural interior decorations remains. Scores of the statues, each a masterpiece of art, are ruined, and fully half of the glass is destroyed. What may be the possibility of restoration remains a question for future investigation, but in any case this task must be a question of years, especially in view of the impoverished condition of the country. The same, or worse, conditions prevail in many other cases.

Whether the old glories and beauties of these structures can be revived is problematic. When these historic buildings were erected—and it was the work of many years, sometimes centuries—it was the custom of these old Continental cities to build their art into their cathedrals and other public buildings, and their decorations were the result of loving efforts by hosts of artists of every kind who dedicated their skill to the public and to the world, and their wanton destruction is an offense and an injury to every lover of the beautiful, of whatever country.

To some small extent efforts were made to protect at least a portion of the exposed decorations, but at best it was possible to cover but an insignificant portion of the ornamental work. The picture on the cover and the accompanying illustrations show how barriers of sand bags have been thrown up for protective purposes, but it is evident that these would be efficient only against shrapnel or the smaller sizes of shells.

Side view of the protection at Amiens.

How Much Sulphur in Steel?

Sulphur in steel has had such a bad name that every case of poor working of the metal is usually laid at its door. That the accusation is unfounded in many cases, or at least that it could be readily and entirely overcome by proper methods of working, is now asserted by an expert of one of the steel companies in a paper recently presented at a meeting of the Society of Automobile Engineers. The matter is an important one, because low sulphur ores are getting scarcer, while on the other hand buyers are showing an increasing tendency to lower limits for sulphur in their specifications.

To test the question practically three heats of sixty-eight tons each were made. These were low sulphur basic open-hearth steels of soft, medium and moderately hard varieties of approximately 50,000, 70,000 and 90,000 pounds tensile strength, the carbon contents being 0.09, 0.32 and 0.51 per cent, respectively.

No selection of stock or furnace was made, the furnaces being taken at random. The heats were cast into twenty-four 18-inch by 20-inch ingots of 6,300 pounds each. Twelve ingots from each heat were used in the investigation, or a total of one hundred tons. After a discard had been made to eliminate any highly segregated or streaked condition in the steel and the regular waste provided for, about fifty tons of steel were used in the tests carried out.

The sulphur content of the ingots was increased progressively by adding amounts of sulphur to different ingots from the same heat, raising the amounts in the higher sulphur ingots of the series greatly beyond that ordinarily found in commercial steels, until a point was reached at which it was difficult, if not impossible, to roll the ingots by the usual heating and rolling operations commonly practised at the mills.

The sulphur additions were made in the pure powdered form to the ingots during pouring. Pyrites was considered, but discarded as a possible means of introducing variables. The additions were regulated to secure as nearly as possible a uniform increase of 0.030 per cent sulphur from one ingot to the next higher. The aim was to obtain steels that, excepting sulphur, would be alike in manufacture and composition, thus keeping out any variables and furnishing an opportunity to study the effect of sulphur alone.

The ingots were rolled into such sizes as would be needed to fabricate the different steels, either by hot or cold working, into such finished articles as they were best adapted to by composition. Sheets, wire products, rivets, chains, tubes, channels, plates, rails, axles and drop forgings were made.

An elaborate series of tests with the different grades of steel, and each with varying percentages of sulphur, were made, including both hot and cold working, welding, drop-forging, case-hardening and machining qualities, and the results apparently bear out the claim made that "a steel containing less than 0.100 per cent is not necessarily bad, and that it will show little, if any, difference in quality when compared with the same steel of much lower sulphur, other conditions being the same."

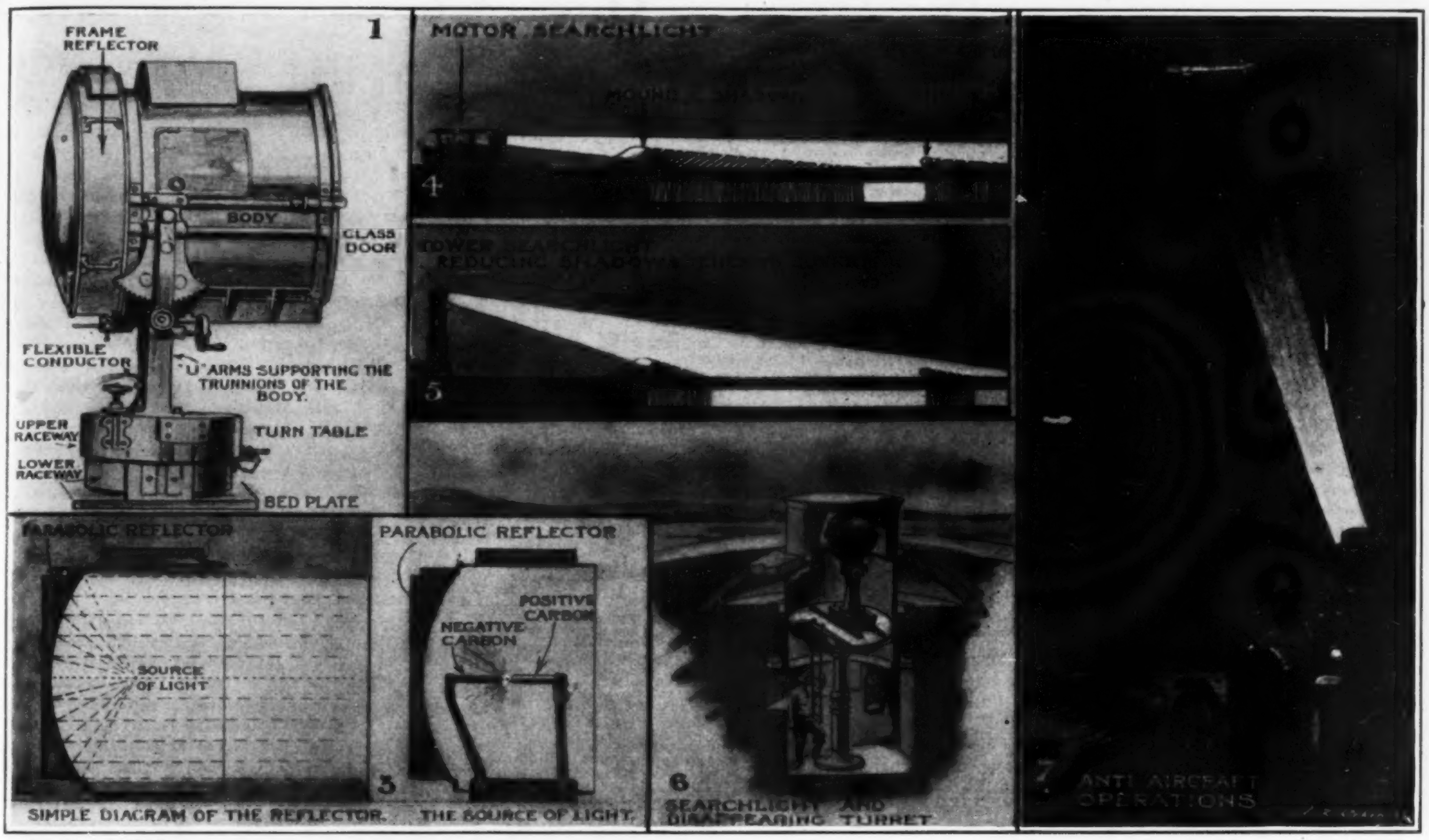
Reinforced Aluminium Electric Cables

According to the *Canadian Electrical News*, ordinary aluminium conductors cannot be pulled up as tightly as copper owing to the lower tensile strength; thus on transmission lines, the greater sag necessitates higher and more expensive towers; and the economy resulting from the use of Al is counterbalanced by the extra cost of the towers. Therefore Al conductors with a steel center cable have been introduced during the last 10 years and are now widely employed. The simplest form is that in which six Al strands are laid round a central steel wire: in the larger sizes, the steel wire is replaced by a 7-wire steel cable: in the largest size, the steel cable has 37 or 61 strands.

For the usual sizes and spans the deflection of steel-reinforced conductors is only 60 or 70 per cent of that occurring with copper: this contributes to a decrease in the cost of the towers. The increased windage and impedance due to the steel center are of no great importance.

Osseine from Bones

In a paper read before the Académie de Médecine, Dr. Maurin points out the fact that on account of the present incomplete utilization of bones, large quantities of alimentary products are lost, and such substances have a great value. For instance, osseine is a substance extracted from bones by treating them with hydrochloric acid, and it contains phosphates of various kinds.



From the *Illustrated War News*.

The mechanism of the searchlight and its use against aircraft or for other military purposes.

When the concentrated beam is employed a door in the armor-plate is opened, exposing the face while in use. In defense against torpedo-boat attacks or hostile airships the searchlight is a very valuable instrument. The sudden action of the beam of strong light on an eye whose pupil is dialated to enable it to operate in the dark causes such a strain on the retina that momentary blindness is the result, and if the light be turned on and off at such a speed that the eyes of the attacking crew have no time to adjust themselves between the changes, the men become practically blind for the time being. A searchlight used for signaling has a diaphragm-shutter similar to that in a photographic-camera. For searchlight work a continuous current is preferable, the effect of an alternating current causing irregular lighting.

Searchlights in War

How They Are Used on Land and Sea

THE searchlight used by the naval and military authorities is a device by means of which the light given by an electric arc is projected in any desired direction.

In order that the maximum effect may be obtained from a given lamp it is necessary to provide a mirror or reflector behind the source of light (Figs. 2 and 3), the mirror being of such a shape that all the rays which do not naturally take that course are reflected in the desired direction (Fig. 2). The electrodes between which the arc-light is produced are mounted in a metal cylinder having a glass face in front of the arc, the before-mentioned mirror being fixed at the back of the cylinder behind the arc. The cylinder itself is mounted in such a manner that it may be moved in any direction so as to bear on any desired object (Figs. 1, 4, 5 and 7). When the face consists of flat, plain glass, the rays are projected to the maximum distance in parallel lines, forming a concentrated beam, but the area illuminated is limited. A larger area in the vicinity of the searchlight itself can be illuminated if the glass forming the face be constructed in such a manner as to disperse the light. Searchlights are used for battleships, fortresses, field work and anti-aircraft operations (Fig. 7).

The plant for use in the field is, of course, much less powerful than for battleships or fortresses, as the question of transport over all sorts of difficult country precludes the use of the heavy machinery required for long-distance work. A large field outfit comprises a power wagon, carrying a dynamo driven by a gasoline engine and capable of giving a current of about 60 amperes, and a searchlight wagon accommodating a searchlight having a 60-centimeter mirror and a reel of insulating cable for use in coupling the searchlight to the motor. In some cases the latter wagon is so constructed as to form a light-tower, from the top of which the searchlight can be operated so as to get a greater range and also to shorten the shadows and in that way reduce the enemy's cover. (See Fig. 5 contrasted with Fig. 4.) A plant of this power will show up individual men at a distance of 2,300 yards when the concentrated beam is used, and at slightly over 1,000 yards with a disperser-face spreading the light over an angle of 45 degrees. A light self-contained plant carried on an automobile is used in present-day field operations.

For fixed work in a fortress or battleship, a much more powerful plant can be employed, having a mirror large enough to throw a concentrated beam giving effective service up to about 3,900 yards. The power plant in the case of a fortress can be fixed at a distance and the current conveyed in underground cables, which may be connected to switch-boxes at intervals around the fortress, so as to permit of the searchlight being

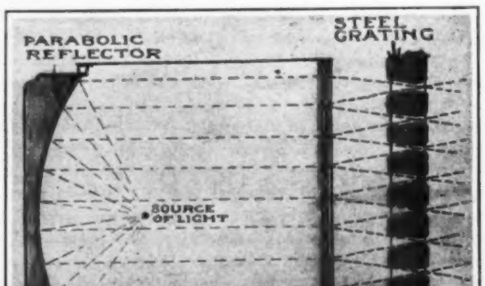


Fig. 8.—How a searchlight is protected in exposed positions: A grating of armor-plate before the face when used for dispersed light.

This diagram is a plan, or top view.

moved from point to point and connected to the nearest box. In some cases the instrument is mounted in a disappearing turret (Fig. 6), which falls below the ground level when not in use, and which is made to revolve on its vertical axis so as to throw its light in any desired direction. A searchlight may be protected from direct fire while in use by sinking it in a pit below the ground-level and projecting its beam of light onto a sloping mirror, but unless it has a further protection it is vulnerable to a plunging fire. When used in exposed positions, the searchlight may be surrounded with armor-plating (Fig. 8), the plate in front of the face when the instrument is used for dispersed light taking the form of a grating consisting of strong steel bars, so placed as to fall into the dark spaces between the rays of light projected from the disperser. —*The Illustrated War News*.

I'Sano Oil

THE I'Sano tree, which grows in the Congo region, produces an oil of some value for industrial use. The fruit of this tree contains a large seed with thin shell and fleshy substance which yields no less than 35 per cent of a somewhat viscous oil. Such oil is of the kind known as drying oil, and consists of a mixture of glycerides of oleic, linoleic and isanic acids. It appears probable that a good commercial use can be made of this I'Sano oil, as in the Congo region it could be produced in large quantities, and it will be valuable for some purposes on account of its rapid drying qualities. Messrs. Herbert and Heim found that when cold or somewhat warm this oil alone or mixed with various siccatives does not oxidize or solidify except after a long time, and in this case it is of little use, but when the oil is heated alone or with other siccative between 120 to 150 deg. Cent. for several hours, it then solidifies rapidly when cold. In this process it is best to add bioxide of manganese or litharge, though a simple heating will answer the purpose. It will be seen that the I'Sano oil could be used for the manufacture of varnishes in the same way as linseed oil.

Oil-Burning Stand-by Plants

THE greatest advantage of oil as a fuel in such plants, says a writer in *Power*, is the rapidity with which a fire can be started; a full fire being had in 30 seconds, a coal fire takes half an hour. No banked fires are needed. The fire is put out and the damper shut tight; by opening the damper and lighting the fire for a few minutes every hour, practically full boiler pressure can be maintained.

Our Merchant Marine—I*

What It Has Been, What It Is and What It Ought to Be

A CONCISE account of the rise and decline of our overseas shipping industry is helpful to a right understanding of the present-day problem of the American merchant marine. This problem relates wholly to that part of our merchant marine that is engaged in the external trade of the United States—the trade with the ports of foreign nations. The home trade of the United States on ocean, lake or river has been reserved to American vessels ever since the founding of the Federal government. Under this policy our coastwise tonnage has grown steadily from 68,607 in 1789 to 6,852,536 in 1914. This is incomparably the greatest coastwise shipping in the world, greater than the entire coastwise and overseas tonnage of the German Empire, or equivalent to threefold the entire tonnage of France or Norway and fourfold the tonnage of Japan. American coastwise navigation is a well-developed and reasonably prosperous business, a trade of vigorous competition, dominated by no trust or monopoly and steadily and swiftly growing. It needs no more national encouragement and it asks none.

But with the shipping registered for trade overseas it is very different. Normally, this should be by far the larger proportion of our merchant marine; actually, it has shrunk to such relative insignificance that on June 30th, 1914, one month before the outbreak of the European war, our shipping registered for foreign commerce amounted to only 1,066,288 tons, or less than one sixth of our home trade shipping.

More than a century ago, in the year 1810, the United States, with only one fourteenth of the population of to-day, had 981,019 tons of shipping registered for foreign commerce, and was carrying under its own flag 91.5 per cent of its own imports and exports. In the fiscal year 1914, American ships conveyed only 8.6 per cent of our imports and exports.

This very great expansion of our coastwise shipping, even against the intensifying competition of the railroads, stands in sharp contrast with the long decline of our overseas shipping, and is manifestly to be explained by the fact that in the one trade it is American against American, with substantial equality in wages and other conditions, while in the other it is American against foreigner, with the overwhelming advantage of lower wages and requirements and certain powerful forms of national assistance on the foreign side.

EARLY SHIPPING LAWS.

Though Americans of the colonial period won success as shipbuilders and seamen, the effect of the Revolution was such that at its end, in "the critical period of American history," most of our overseas carrying trade fell into the hands of British shipowners. Our entire merchant fleet registered for foreign commerce amounted to only 123,893 tons in 1789, and only 23.6 per cent of our own trade was being conveyed in American vessels. In other words, the condition of the ocean shipping business of this country, when the Federal Constitution was adopted and Washington became the first President, was not very unlike its condition now.

Washington, Adams, Jefferson and Madison all joined in urging immediate relief for the merchant shipping industry, and the very first act of the first Congress under the new Constitution, passed on July 4th, 1789, "for the support of the Government, the discharge of the debts of the United States and the encouragement and protection of manufactures," contained an important clause allowing a discount of 10 per cent of the tariff duties on all goods imported in ships built and owned by American citizens. Moreover, on tea imported direct from the East Indies in American vessels a further and far heavier rebate was provided, and the third act of this new Congress, on July 20th, 1789, gave American vessels a marked preference in tonnage duties and virtually barred foreign vessels from the coastwise trade. In 1794, in place of a discount of 10 per cent in the tariff duties on goods imported in American vessels, 10 per cent was added to the duties on goods imported in foreign vessels—a change of method, but not of principle. There was no sectional or party division over this early legislation for the encouragement of the American merchant marine. Thomas Jefferson of Virginia, then Secretary of State, wrote in 1794, "To force shipbuilding is to establish ship yards; is to form magazines; to multiply useful hands; to produce artists and workmen of every kind who may be found at once for the peaceful speculations of commerce and for the terrible wants of war."

SUCCESS OF THE PREFERENTIAL DUTIES.

These laws of the founders of our Government, so frankly and strongly preferential to American shipping, instantly destroyed the British monopoly of three quarters of our ocean carrying. As a historian of the period has well said, "The growth of American shipping from 1789 to 1807 is without parallel in the history of the commercial world." American tonnage registered for overseas commerce increased at once from 123,893 in 1789 to 346,254 in 1790, 363,110 in 1791 and 411,438 in 1792. It was at this time and under this policy that Boston and Salem laid the foundations of their great East India commerce. The proportion of our total imports and exports carried in American ships rose from 23.6 per cent in 1789 to 40.5 per cent in 1790, to 55.9 per cent in 1791 and to 64 per cent in 1792. By 1795 no less than 90 per cent of our commerce was conveyed in American vessels. Foreign flags, which a few years before had dominated our commerce almost as completely as they do to-day, well-nigh vanished from our ports of the North Atlantic. In 1800 there were 667,107 tons of American shipping registered for overseas voyages, and in 1810, 981,019 tons.

This wonderful growth of our ocean fleet was achieved, in spite of European impressment and embargo, through the power of wise laws which made it advantageous for American merchants to employ American vessels whenever they had occasion to bring goods from foreign lands—and preferring these ships for the import trade, they naturally utilized them for the export trade also. Thus assured of constant employment, American shipowners, building many vessels in succession from the cheap and abundant timber of the Atlantic coast, developed models that combined capacity with speed, and American officers and crews navigated them with the utmost skill and daring. National encouragement of this maritime industry had quickly produced a smartness and efficiency, the like of which the world had never seen.

MISNAMED "RECIPROCITY" AND ITS RESULTS.

So confident had our statesmen grown of the superiority of American ships under any circumstances that in a commercial convention with the British government, framed shortly after the end of the naval war of 1812-1815, the United States withdrew its preferential duties as against British ships in the "direct" trade with the United Kingdom. Moreover, under pressure from inland and agricultural interests our Government, through commercial treaties and acts of Congress, gradually withdrew the shipping preference from other trades, though this was not completely effective until 1850, against our chief competitor, Great Britain. These "reciprocity" acts were passed in the face of the earnest protests of the merchants and shipowners of the coast, who best understood the situation.

American shipping continued to grow slowly up to the Mexican war period, but there was not again such a marvelous expansion as that of 1789-1810. In 1832 a tonnage of 614,121 was registered under the flag of the United States, carrying 83.1 per cent of our imports and exports; in 1845 a tonnage of 904,476, carrying 81.7 per cent. Foreign vessels were figuring more largely in our overseas trade, but on the other hand, our ships were conveying a part of the trade of other nations. Just how reciprocity on the sea would have resulted in the long run cannot be known, for it soon proved that it was not real reciprocity at all, but something very different and delusive. The United States in entire good faith, in the years between 1815 and 1850, entered into commercial agreements with foreign governments that ships of either nation should be admitted on terms of equality into the ports of the other so far as tariff and tonnage duties, etc., were concerned. In other words, the preference or encouragement which Washington, Adams, Jefferson, and Madison had given to American shipping was step by step abandoned. One result was that British ships, manned at a lower wage scale, increased nearly 400 per cent in our own ports between 1831 and 1840, while our ships gained but 40 per cent in all the ports of the world.

BRITISH SUBSIDIES TO STEAMSHIPS.

This was while the competition was with sail ships, wooden-built, on either side. But just before 1840 the British government began to invoke a new form of encouragement. In 1834 a subsidy of $85,000 a year was given to the Rotterdam and Hamburg steam packets of a British company, and another subsidy of $150,000 to the packet service to Gibraltar. These British royal payments were found to be so valuable in their influence on the new art of steamship and engine building in the United Kingdom that in 1838 another and much larger subsidy was offered for a British steamship service across the North Atlantic. In the year following a subsidy of $425,000 a year was secured by Samuel Cunard for a steam line from Liverpool to Halifax and Boston. "It is beyond question," declares James Russell Soley, the historian, "that the sum paid to the Cunard Company in its early days, amounting to about 25 per cent per annum on the cost of the running plant, and subsequently increased to $550,000, to $750,000 and to $850,000, was clearly a subsidy; that it was given with the plain intention of establishing firmly in English hands the transatlantic traffic, and that it accomplished the desired result."

Other British subsidies quickly followed the Cunard—to the Royal Mail Steam Packet Company, for lines to the West Indies, Brazil and Argentina, to the Pacific Steam Navigation Company for a line to the west coast of South America (this was established by an American, William Wheelwright of Newburyport, who had first sought a subsidy in vain in Washington), to the Peninsular & Oriental for lines to the East Indies and to other companies in all quarters of the world. In a few years British subsidies totaled $3,000,000 or $4,000,000 annually.

The United States had been outwitted by British diplomacy and statesmanship. First, the preferential policy of Washington and his colleagues had made American shipping the most prosperous in existence. "That starred flag," the London *Times* lamented, "is now conspicuous on every sea, and will soon defy our thunder." But we were adroitly persuaded to lay aside the weapons that had served so well, and when we had bound ourselves by solemn treaty no longer to employ them, the British government introduced the new and potent expedient of subsidy which the treaties and agreements did not forbid.

AMERICA ADOPTS SUBSIDIES ALSO.

This new departure did not pass unchallenged in the United States. It is almost forgotten now, but it is a fact of record that the American Government for a time resolutely met subsidy by subsidy and was brilliantly successful in the contest. It was an American, Fulton, who created the first efficient steamboat, in the "Clermont" of 1807. Steam craft came into immediate use on rivers, sounds and bays here, and in 1830 appeared in the ocean coast trade. Ericsson, with his screw propeller, was rebuffed in England, but received and honored here, and in 1841 the first seagoing screw steamship was built for an American line from New York to Havana. At that period when the Cunard subsidies began, the United States was clearly ahead of Great Britain in steam navigation. Moreover, ships had begun to be built of iron here, the "Bangor," for example, for New England coast service, in 1844. American ingenuity and enterprise were as quick and competent to deal with steam as with sail, with metal as with wood. The idea that iron steamships could not be built in the United States before the civil war is the invention of malice or of ignorance.

It is a profoundly significant fact that the initiative in the movement to meet British steamship subsidies by American subsidies was taken by Southern men who were Democrats in national politics. Senator Thomas Butler King of Georgia was the pioneer. In 1841, soon after the first Cunard steamers had reached the United States, he began to advocate in Congress the granting of mail subsidies, no less liberal than the British, to put the American flag into equal competition. "British statesmen," he said, "are resolved to monopolize the intercourse between America and Europe. Of all the lines of sail packets which cross the Atlantic not one is owned in Europe, and it is not to be doubted that American merchants, properly encouraged, will assuredly excel in them (steamship lines) as they have done in sailing vessels."

President Polk, a Southern man and a Democrat, advocated subsidy legislation in his message to Congress. "The national policy," he said, "by which a rapid communication with the various distant ports of the world is established, by means of American-built steamers, would find an ample reward in the increase of our commerce, and in making our country and its resources favorably known abroad"—but President Polk went on to argue that the national advantage was "still greater of having powerful steamships available for war," and "having the privilege of taking the ships already equipped for immediate service at a moment's notice." This, he declared, "will be cheaply purchased by the compensation to be paid for the transportation of the mail over and above the postage received. A just national pride, no less than our commercial interests, would seem to favor the policy of augmenting the number of this description of vessels."

* A report of a special committee of the Boston Chamber of Commerce.

THE COLLINS AMERICAN LINE.

So a Southern Democratic President wrote, and a Democratic Congress acted on his recommendations, the project being supported by members of Congress without regard to party distinctions. A subsidy of $200,000 was granted to a new American steamship line to Havre and Bremen—less than half the sum paid to the Cunard Line, and the American ships were larger. This was under the ocean mail laws of 1845 and 1847, by which additional American steamship services were established to the West Indies, the Isthmus of Panama and up the Pacific coast to Oregon.

In 1847 a contract was concluded by our Government with the head of the celebrated Collins Line of transatlantic steamers for a subsidy of $385,000 a year. When Mr. Collins built steamships much larger and more powerful than the Cunard ships his subsidy was increased to $858,000 a year—the Cunard Line was then receiving $856,000 from the British government. This new American line began under the brightest auspices. Its steamers beat the Cunard steamers regularly in passages from land to land and secured the bulk of the first-class passenger traffic. Moreover, as Lindsay, the historian of British shipping, said, "Before the Collins Line was established the Cunard steamers were receiving £7 10s. sterling per ton for freight, which was so much a monopoly rate that in two years after the Collins Line had commenced the rate of freight fell to £4 sterling per ton." Under the impulse of the mail subsidies, American ocean steam shipping rose from 16,068 tons in 1848 to 115,045 tons in 1855. As Dr. David A. Wells says of the period:

"During the single year 1849-50 we increased our ocean steam tonnage one hundred and thirteen per cent, and the seagoing qualities and performances of our vessels were so admirable that the Cunard Company, which had then been in operation ten years, was obliged to bring out new ships to compete with them. The prospect, therefore, at one time was that the United States, although late in the start in this new department of foreign shipping, would soon equal, if not overtake, her great commercial competitor."

It was an era also of immense expansion in the sail shipping of America, due to a succession of extraordinary causes—the famine of 1847 in Ireland and an abnormal demand for foodstuffs in Europe, the gold rush of 1849 to California and the Crimean war of 1854-1856. The famous American clippers, built particularly for the California and China trade, belonged to this era, when in 1855 no less than 583,450 tons of shipping, including 381 ships and barks, were launched from American yards.

LOSING OUR SHIPS BEFORE THE WAR.

In that year, 1855, the American merchant marine in overseas commerce reached its climax. There set in immediately a sharp and startling decline—six years before the civil war. Though the tonnage nominally registered for foreign carrying did not immediately show a decrease, shipbuilding fell off from 583,450 tons in 1855 to 156,602 tons in 1859, and rallied only to 214,797 tons in 1860. This heavy shrinkage in the product of the shipyards indicated that six years before the first shot was fired at Fort Sumter, grave discouragement and disaster had befallen our merchant marine. This historic fact is exceedingly important to remember, because it has so often been asserted that the loss of our ocean shipping began with and was wholly due to the great war between North and South. The records of shipbuilding afford conclusive proof that the decline had set in long beforehand.

The causes of this decline were in part economic, but in much larger part political. It has often been alleged or assumed that the change from sail to steam and from wood to iron gave Great Britain, our old and formidable rival, an overwhelming advantage over the United States. But the United States in 1855 had long been building steamships for coastwise navigation; some of these were iron ships, and American-made iron was declared by architects and engineers to be the very best for maritime construction. There were iron shipbuilding plants at New York and Philadelphia and, before 1860, at Boston. It was a period of low tariff for revenue only, and the high customs and internal revenue taxation of the civil war, that undoubtedly for a time did burden the shipbuilding industry, had not come into existence. Americans were naturally as adept at iron working and at boiler and engine building as their British kinsmen—a fact soon to be demonstrated to all the world by the great armorclad fleet of the Federal Navy.

Great Britain, in 1855, was manufacturing more iron than the United States, and to a certain degree the transition, from a material of which the United Kingdom produced almost none at all to a material which it possessed in particular abundance, was a benefit to British yards, but it was by no means a conclusive factor. There was enough iron of admirable quality in America for the construction of a great fleet of ships. For the main cause of the decline of our ocean shipping from its climax of 1855 to the outbreak of the civil war it is necessary to look in quite a different direction.

AMERICANS AHEAD IN STEAMSHIPS.

Rivalry between American and British ocean steamship lines on the North Atlantic from 1850 to 1855 had demonstrated that the Yankees were as skillful in engineering as they had long been in seamanship. Capt. McKinnon, of the British navy, after voyages of observation in both the Collins and Cunard lines, reported to his government that "there are no ocean steamers in England comparable with the (American) 'Baltic.'"

But there was one serious weakness in the situation. All of the new American ocean steamers were built in the North, owned and manned by Northern men, and registered at Northern seaports. The sectional slavery feud between the States was growing more and more bitter every day, and Southern men were in control in Washington. These ocean steamships, maintained by subsidy from the National Treasury against their equally subsidized British rivals, were a formidable addition to the commercial and naval power of the North. For the same reasons why the strengthening of the Federal Navy was suspended, the mail subsidies were taken away from the great, successful American ocean steamship services in the very crises of their contest with their British competitors.

OUR SHIPPING THE VICTIM OF SECTIONAL ATTACK.

This was done, after a memorable struggle, in 1856 and 1858, under the direction of several distinguished Southern men, Jefferson Davis, of Mississippi, afterward President of the Confederacy; R. M. T. Hunter of Virginia, afterward Confederate Secretary of State; S. R. Mallory of Florida, Confederate Secretary of the Navy; Robert Toombs of Georgia, a leading member of the Confederate Congress and Secretary of State; Judah P. Benjamin of Louisiana, Confederate Attorney General; and J. M. Mason of Virginia, well remembered with Mr. Slidell as Confederate envoy to Europe.

These able and eminent Southern statesmen doubtless believed that they were serving vital interests of their own people, but not all of their own section coincided in their action. Though they received some help from agricultural States of the West and Southwest, Senator Bayard of Delaware eloquently protested against the abandonment of American steamship enterprise as a surrender to the British government, and the action of Congress in withdrawing the subsidies was generally condemned by men of all parties in the North as blindly sectional and disastrous.

HOW BRITISH SUBSIDIES WON.

Disastrous, indeed, it quickly proved. When, in 1856, the Southern lawmakers reduced the Collins mail pay from $858,000 to $385,000—the British Cunard ships were then receiving $856,000—the managers of the chief American line to Europe refused to give up the fight, and struggled on for a time. But the odds were hopeless, and they were forced to quit the field. Their largest ship, the splendid "Adriatic," was sold to a new British subsidized line from Galway and held the Atlantic record under the British flag. One by one the other American Atlantic lines succumbed, and when Commodore Vanderbilt, with all his wealth and genius, attempted to compete with the British subsidized lines, he was unable to withstand the treasury of the British government. When the civil war opened in 1861, only occasional American steamships were running to Europe. British subsidies had won the fight.

The Collins Company had lost two steamships by wreck, and its failure is sometimes attributed to this misfortune. But many more ships were lost by the British Atlantic lines. The Royal Mail had seven steamers destroyed in quick succession. But the British government, instead of abandoning the Royal Mail, stood by it more resolutely than before, and enabled it to build new ships and maintain its service.

Perhaps the greatest New York merchant and shipowner of this time was A. A. Low, Esq., the distinguished father of Hon. Seth Low, formerly mayor of New York and president of Columbia University, and now president of the New York Chamber of Commerce. The elder Low, in a formal statement to Congress, speaking as an eye witness thoroughly familiar with the facts, declared:

"I only know the English have always, in peace and war, manifested a determination to hold the supremacy on the ocean, and the supremacy which they acquired by arms in war they have in peace acquired by subsidies. They have deliberately and intentionally driven the Americans from the ocean by paying subsidies which they knew our Congress would not pay. . . . They have driven us from the ocean by that policy just as effectually as they ever did drive an enemy from the ocean by their guns."

Great Britain, in 1860-1861, was expending $4,537,223 in the encouragement of steamship building and mail communication with all parts of the world. France, following the British example, in 1858 offered subsidies of $620,000 a year for a line from Havre to New York, $940,000 for a service to Brazil and $1,300,000 for a service to the West Indies and Mexico. Germany, at about the same time, began to subsidize the North German Lloyd on the routes from which the swift American ships had disappeared. The slavery feud had killed the American merchant marine in transatlantic commerce.

EFFECTS OF THE CIVIL WAR.

After the destruction of transatlantic mail lines came the civil war. Anglo-Confederate cruisers between 1861 and 1865 burned or sank 110,000 tons of American shipping, and drove 751,595 tons under foreign colors—nearly one third of our whole fleet registered for overseas carrying. This ocean trade fleet, which had amounted to 2,496,894 tons in 1861, controlling 65.2 per cent of our imports and exports, had shrunk to 1,387,756 tons in 1866, controlling only 32.2 per cent of our imports and exports.

For a while after the war our ocean shipping actually increased. Shipowners and builders would not surrender without another effort. Our registered tonnage in 1867 reached 1,515,648 and remained at or near the same figures for a decade thereafter—the total registered tonnage in 1878 was 1,589,348. But in this same period the proportion of our imports and exports carried in American vessels had steadily decreased from 33.9 to 26.3 per cent, and after 1878 both total tonnage and proportionate carrying fell together, reaching a tonnage minimum of 726,213 in 1898, and a proportionate carrying minimum of 8.2 per cent in 1901. From 1898 onward there has been a gradual, though not constant, increase in our registered tonnage to the 1,066,288 tons of 1914. But this increase is more apparent than real, for it includes a considerable fleet of vessels employed in the long voyage coast trades like that *via* the Panama Canal. These vessels and others passing near or by foreign ports sail under register instead of enrollment, for purposes of safety and convenience. There was virtually no real increase, up to the opening of the present European war, in the proportion of our imports and exports carried under the American flag. From 8.2 per cent in 1901 this rose to 12.1 in 1905, but fell again to 8.6 per cent in 1914. The development of American ocean shipping when this great war started was substantially where it had been sixteen years before.

(To be continued.)

Simple Process for Purifying Mercury

MERCURY which has been more or less long in service in a laboratory, gradually becomes contaminated by dust and dirt and amalgams of zinc, lead, copper, tin, etc., formed within it. It can be purified by a series of distillations in vacuum, which is a lengthy process, or by chemical methods (treatment with nitric acid), which takes still longer. We learn from *La Nature* that M. Margot of Geneva has just perfected an old chemical process, which is both simple and effective. It consists in passing through the heated mercury a current of air which oxidizes the metals held in solution. The apparatus comprises an iron tube 1.6 meters long and 3 centimeters in diameter. This is held by two supports in a slightly inclined position. At the two extremities of the tube two tubular openings or necks are attached, one serving to admit air, the other to admit mercury. A Bunsen burner provides the heat required, which is from 150 to 160 deg. Cent. With this apparatus 10 kilogrammes of mercury can be purified in 24 hours. If a current of hot air is also used the purification is said to be more complete.

Sharpening Files by a Sand Blast

ACCORDING to *The Engineer*, a sand-blasting apparatus for file sharpening now in use consists of a sheet-iron chamber provided with uptake, settling tank, slurry mixing tank, slurry overflow pipe, air-agitating pipe and slurry projector. A door gives access to the inside of the chamber. The slurry projector is inclined to the horizontal at an angle of 25 degrees, and the nozzle extends slightly within the chamber. This projector consists essentially of a bronze body to which are fitted the steam pipe, slurry suction pipe and nozzle. The steam supplies sufficient water for the slurry. The files are sharpened by being held in a slurry jet in such a manner as to expose the backs of the file teeth to the cutting action of the sand. The success obtained in file sharpening depends on the skillful selection of the files to be sharpened, maintenance of the correct angle between files and jet while sharpening, and the selection of a suitable sand. Experience shows that a sharpened file often does as much work as a new one, and the cost of sharpening averages about one fifth of the cost of new files.

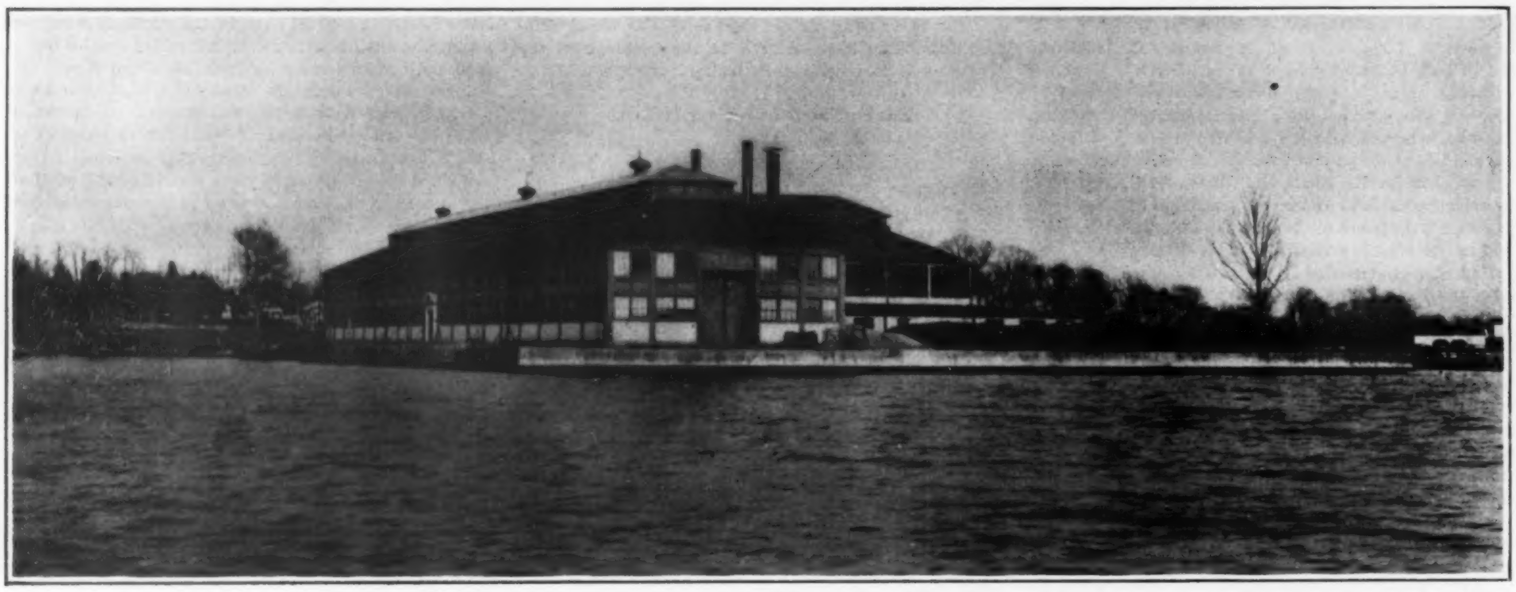


Fig. 1.—The U. S. Engineering Experiment Station at Annapolis.

The U. S. Naval Engineering Experiment Station

A Valuable But Little Known Enterprise at Annapolis, Md.

By Wm. L. DeBaufre, E.E., M.E.

In the editorial in the Scientific American for October 23rd, 1915, entitled "A Laboratory—Not a Navy Yard," no mention was made of the U. S. Naval Engineering Experiment Station as already at the disposal of the Navy Department. Apparently it is generally not appreciated that the Navy now possesses laboratories for scientific engineering investigations, nor that considerable experimental and research work has already been accomplished by the several bureaus of the Department.

The Navy Department is organized mainly by bureaus. The Bureau of Construction and Repair is concerned with the hull and structure of the ship. The guns and ammunition are under the Bureau of Ordnance. The Bureau of Steam Engineering has charge of the propelling machinery and auxiliaries.

The Experiment Station is under the jurisdiction of the Bureau of Steam Engineering, but experimental work has been done under the direction of that bureau for other bureaus, mainly the first two mentioned, which, with the Bureau of Steam Engineering, are concerned with the three essential parts of a warship.

A model tank is maintained at the Washington Navy Yard under the Bureau of Construction and Repair, for determining the power to drive ships of different shapes through the water; but this model tank has also been used for particular investigations, for example, to determine the suction exerted by one ship upon others in passing. The performances of various ventilating fans have also been determined by this bureau. The Bureau of Ordnance has laboratories at Indian Head, Md., near Washington, for tests upon ordnance and ammunition, and is investigating and developing torpedoes at Newport, R. I. The bulk of the experimental work for the Bureau of Steam Engineering is done at the Naval Engineering Experiment Station, Annapolis, Md., but some routine tests upon gages and thermometers and certain electrical testing are conducted at the Brooklyn Navy Yard.

The U. S. Naval Engineering Experiment Station was established by an act passed March 3rd, 1903, by the Fifty-seventh Congress, appropriating $250,000 for a building and $150,000 for the necessary equipment as an experiment station and testing laboratory. The act specified that the building be built on land owned by the Government; but it was found impracticable to locate the experiment station within the Naval Academy grounds, and some delay was experienced in locating it upon a twenty-acre tract of land across the Severn River from the Naval Academy, where the building was finally erected during the years 1906–1908. The installation of equipment was fairly well completed in August, 1908. The station has therefore been undergoing development in its present location for about seven years.

A general view of the Engineering Experiment Station from the Severn River is shown in Fig. 1. The whole station is contained under one continuous roof, but is divided into the "main building," extending nearly northeast and southwest; the "boiler house," extending from the middle point of the main building at right angles thereto; and several lean-tos around the boiler house. The main building is 316 feet long by 66 feet wide, and is served throughout its length by a 15-ton crane. A view of the northeast end of the main building from the crane is given in Fig. 2. Here are located the office of the head of the station, the offices of the test officers and clerks, the chemical, oil and metallographic laboratories, the drawing room and library, the blue-print and photographic dark rooms, tool and store rooms, and the material testing machines. The southwest end of the main building is seen in Fig. 3. In this end of the building are the foreman's office, the mechanics' locker and wash room, the machine shop, the pattern shop, the experimental steam turbines and condensers, evaporators, the blower chamber, gasoline engines, open and closed tanks, the salt water basin, the pump trench and the testing floor, etc.

In the boiler house are located air compressors, condensers, heaters, pumps, several marine boilers, two closed boiler compartments, three test coal bins, and one of the dynamo rooms (Fig. 4). An oil-burning Mosher type boiler is within the air-tight compartment at the right. In the lean-tos are the coal screening and crushing apparatus at the end of the boiler house, the blacksmith shop, the sheet metal shop, and the foundry on one side, and the instrument and calibration rooms and the dynamo rooms on the other side. In the dynamo rooms are provided a steam turbine direct driven current generator, a Diesel marine type two-cycle engine driving an alternator, a hot bulb type oil engine-driven generator, a steam engine-driven generator, a motor generator, a balancer set and a switchboard. A view in the dynamo rooms is shown in Fig. 5.

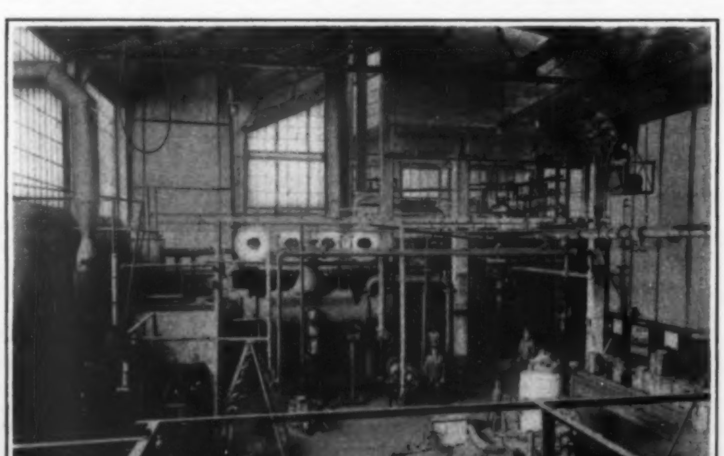


Fig. 4.—The boiler house in which are located dynamos, air compressors, condensers, several marine boilers, etc.

The head of the station is a naval officer. The technical staff of the station is at present composed of two additional naval officers, three mechanical engineers, three chemists, one metallographist, one draftsman and two mechanical laboratorians (special mechanics). There are eighteen laboratory helpers with technical training to assist in recording data and calculating the results of tests. Under a foreman and quarterman are machinists, coppersmith, molder, boiler maker, pipe fitter, blacksmith, pattern maker, general helpers and laborers, to make and set up apparatus for test. To operate the electrical and power plants are employed an electrical mechanic, a dynamo tender, water tenders and firemen. In all, there are now at this station 91 men.

All tests must be authorized by the Bureau of Steam Engineering, but they may originate in the bureau, at the station, or from the request of a manufacturer to have his machine or apparatus tested for determining its suitability for use in the naval service. In the last case, the exhibitor must make a deposit to cover the cost of the test. Manufacturers with worthy apparatus rarely hesitate to make the required deposit, and it is believed that in general the manufacturer has gained sufficient information from the test to warrant the expenditure without regard to possible future use in the Navy.

A test may cover an investigation lasting years, or only a simple determination made in a few hours—but the latter are rare. During the progress of a long test reports may be made from time to time, so that the number of reports are greater than the number of tests. Monthly sheets are sent to the Bureau of Steam Engineering, giving the status of the tests in hand.

A rather brief summary of the work accomplished and in hand is given in the following paragraphs:

Corrosion.—Considerable time has been spent in studying the prevention of corrosion in boilers, and there was developed a compound which proved very successful with fresh water. In marine service, however, leaks are liable to occur, admitting salt to the boilers, and large quantities of salt have been found to destroy the effectiveness of the compound. For this reason, research is now proceeding upon different lines such as the complete elimination of

Fig. 2.—Interior view of the northeast end of the main building.

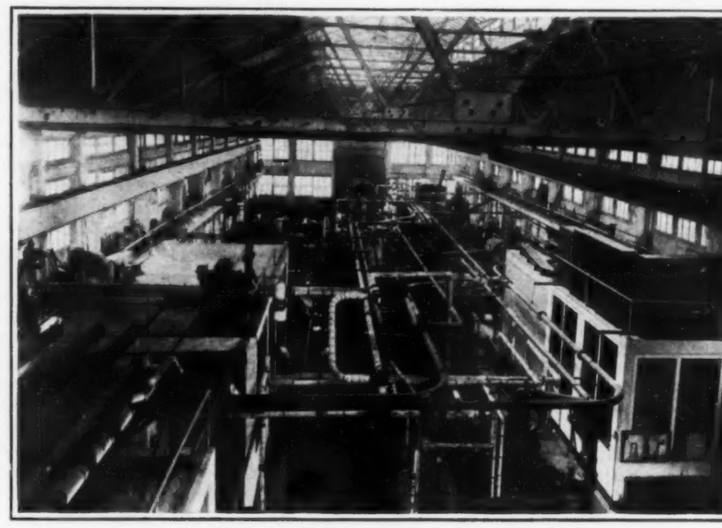


Fig. 3.—Interior view of the southwest end of main building.

free oxygen from the water before entering the boiler.

Coal.—Coal for the Navy is obtained from a number of mines, on a list prepared by the Bureau of Steam Engineering. Before placing another mine upon this list, it is first required that an evaporative test shall be made at the Engineering Experiment Station upon a representative sample of coal. With a marine type of boiler, Navy standard grates, and firemen and officers familiar with the naval service, the coal is subjected to practically the same conditions during the test as it would later be required to undergo if found acceptable. The raising of the old battleship "Maine" gave opportunity to test coal which had been under water fourteen years in Havana harbor. The fifth annual test has just been completed upon Pocohontas coal stored five years at New London, Conn., in three lots, one under salt water, one under shed, and one in the open, to determine the effects of storage. These coal tests, especially the last named, have yielded valuable information regarding the best method of firing soft coal under marine boilers.

Fuel Oil.—The variation of the capacity of several makes of mechanical fuel oil burners has been found with varying oil temperature and pressure. Fuel oil heaters and meters have been tested, and the effects of locating air chambers at different points in a fuel-oil system are about to be investigated.

Lubricating Oil.—Definite specifications for the properties of lubricating oils have been discarded by the Navy Department, and the selection based instead upon passing satisfactorily tests at the Engineering Experiment Station. Chemical analyses, determinations of certain physical properties, and operating tests are made upon the oils submitted by the various refineries. Methods and apparatus were required to be developed for this work, including emulsifying apparatus and friction-testing machines with forced lubrication systems. A view in the oils laboratory is shown in Fig. 6. Close watch is kept upon the performance of lubricating oils in the service, and all defects are traced to their proper causes. This has required research in the proper ways of using lubricating oils. Comparative tests have also been made upon lubricating oil coolers.

Packings.—Packings for steam, water and air joints are tested in the operating equipment, and also in special equipment built for that purpose.

Internal Combustion Engines.—Tests upon aeronautical gasoline engines have been made for both the Navy and the Army. The Diesel marine type reversible two-cycle engine in the dynamo room, Fig. 5, was purchased and installed with the expectation that investigations could be made upon it, but other more urgent work has so far prevented the realization of this expectation.

Steam Turbines.—The first test undertaken by the Station was upon a set of experimental high-pressure Parsons turbines, and numerous tests have since been made upon small turbines driving blowers and pumps.

Reciprocating Pumps.—A number of tests upon nearly all the types of reciprocating feed pumps in use in the service have been completed with both hot and cold water at different piston speeds and water pressures.

Centrifugal Pumps.—Vertical centrifugal feed pumps

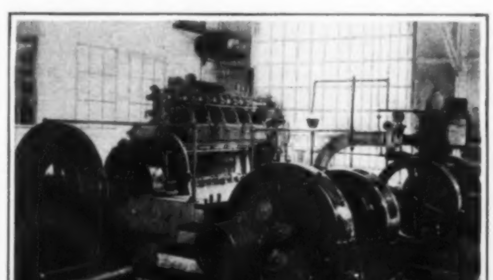


Fig. 5.—Some of the electric machinery and their motors.

for pressures as high as 350 pounds per square inch have been tested for comparison with the reciprocating type. An interesting problem in connection with this type of pump was the determination of the bearing pressures due to gyratory action of the rapidly rotating parts when mounted in a rolling ship at sea.

Rotary Pumps.—Various types of rotary pumps have been tested and few found satisfactory for naval use.

Blowers.—Actual conditions on board ship where the blower withdraws air from the atmosphere and discharges it into the closed fire room, are closely approximated during the test, by connecting either the discharge or the suction duct of the blower to a large air-tight galvanized iron chamber. This chamber is shown in Fig. 3 at the far end of the building, where it is being installed temporarily for the test of a blower for a destroyer.

Feed Water Heaters.—The performance of closed feed water heaters has been extensively investigated, and the results have furnished design data to the Bureau of Steam Engineering by means of which the weight of this apparatus has been considerably reduced

Evaporators.—Bureau and other types of salt water evaporators have been tested to determine the purity of the distilled water with different capacities and methods of operation.

Condensers.—Comparative tests upon condensers were early authorized, but more urgent work and lack of force have prevented more than some preliminary work being accomplished. The condenser shown in Fig. 4 has been only recently installed, and was so designed that various modifications can be made for investigation purposes.

Safety Valves.—These are tested on the oil burning marine boiler, which admits of close regulation of the steam pressure, and is of sufficient size to keep a large valve blowing steadily for two hours to determine its capacity. In the development of this test work, more complete formulas than those generally used have been derived for calculation of the stresses in the springs, and for the flow of steam of different qualities through orifices.

Steam Traps.—To be placed on the acceptable list, a steam trap must satisfactorily withstand a test at this Station, in which the functioning of the trap is investigated at different capacities for the range of steam pressures encountered on warships, from 25 to 300 pounds gauge.

Valves and Boiler Fittings.—In addition to a correct design and the use of proper materials to insure strength and rigidity, a valve should not readily develop leaks, due to cutting or warping of the disks or seats. Hence valves under test are operated manually a number of times daily and the degree of tightness measured by the quantity of steam that leaks through the apparently closed valve. Reducing valves are tested by noting their ability to operate continuously in the service lines of the Station, and the fluctuations in reduced pressure with variations in steam flow are recorded. Boiler bottom blow valves are operated daily and their consequent tightness and durability noted. Gage glasses and gage-glass fittings are tested on auxiliary steam drums where the conditions may be varied at will. Water-level regulators are not considered desirable for use in the naval service, although tests upon them have been made at the Station. Feed-pump governors, however, are in satisfactory use, especially those of the excess pressure type that have been tested here.

Metallography.—The microscopic examination of metals was developed in connection with tests of defective material sent to the Station from the ships in the service. It has now so far developed that specimens are sent for examination from each shaft and coupling before it is accepted for naval use. Research is in progress to determine the relation between the metallographic structure and the physical properties of metals. An investigation is also in progress upon methods of riveting. To facili-

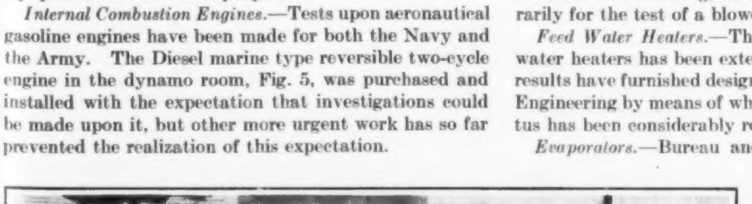


Fig. 6.—A view in the laboratory for investigating oils.

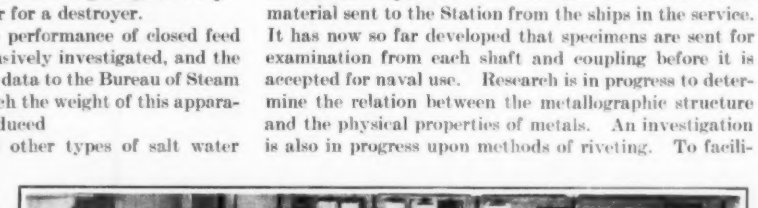


Fig. 7.—The metallographic laboratory.

tate the microscopic examination of large machine parts in place, a portable microscopic mounting has been designed and built at the Station, and is so arranged that the microscope may be focused upon a surface at any angle.

Physical Tests of Metals.—The testing machines seen in Fig. 2 provide for tension, compression, shearing, transverse, single impact, alternating impact, fatigue and hardness tests of materials. These machines are employed to determine the suitability of new materials for specific purposes, to determine the defects, if any, in materials which have failed, and for research along various lines. An investigation is under way of the effect of alkaline solutions upon the strength of steel.

Chemical Tests.—The chemical tests include analyses of bearing metals, boiler-tube materials, valve materials, brasses and bronzes, cast irons and steels, alloys of steel with vanadium, chromium, nickel, etc., monel metal, boiler compounds, boiler deposits and scales, internal combustion engine deposits, lubricating and fuel oils, coal, furnace gas, various brines, etc.

Instruments.—All the instruments used in the test work at the Station must be calibrated and kept in good working order. Some instruments must be calibrated before, after, and even during each test. A number of instruments have been designed and built at the Station for special purposes or to facilitate the work. Tests to determine their suitability for naval use have also been made upon thermometers, pyrometers, pressure gages, speed indicators and tachometers, water and oil meters, torsion meter, etc. In the center of Fig. 2 is seen a displacement meter mounted for test upon an oscillating platform, to simulate the motion it would have on a rolling ship.

Miscellaneous Tests.—In addition to the tests coming under the preceding headings, a number of miscellaneous tests have been made, among which may be mentioned: Methods of galvanizing, methods of welding, ball and roller bearings, expansion sleeves, lock nuts and washers, whistles operated by air and steam, flexible couplings, grease cups, fire brick baffles, fire cement, boiler tube cleaners, water circulation in boilers, rotary engines, paraffin illuminants, gasoline drums, friction clutch, steam pipe insulations, bearings and bearing metals, refrigerating machines, smoke preventatives, steam hose, pipe wrenches, pipe unions, files, etc.

The above summary of the character of the tests completed and in hand will give some idea of the variety of work covered at the Naval Engineering Experiment Station or naval laboratory for the Bureau of Steam Engineering. With the help of the data obtained, reduction in weight and increased efficiency in operation of machinery on shipboard have resulted. The grades of materials purchased have been improved and better adapted to the services required, although their cost has decreased. For example, the cost of packing has decreased during the past five years to one third of its former cost, and less of it is required. Although the cost of lubricating oil has decreased in like proportion, less lubrication troubles are experienced. Thus, not only has a basis been prepared for future development, but much valuable work has already been accomplished.

In spite of the increased efforts of the technical staff, as shown by the greater number of reports made per year, the tests in hand at the end of each fiscal year have also increased. Congress has shown its appreciation by increasing the appropriations from time to time. Neither the appropriations nor the staff, however, have increased commensurately with the work assigned for the Station to do. The photographs reveal the overcrowded condition of all the laboratories.

The tests are becoming more miscellaneous in character and longer investigations are being required. These investigations grow out of what is at first a short routine or miscellaneous test. Thus, there is a blending of routine and research work, which is beneficial to both. The routine tests in direct connection with actual conditions keep the investigator down to a practical basis in his research work, an essential at least in engineering research. On the other hand, his research investigations enable the test officer to deal better with routine work than he would otherwise be prepared to do.

The Improvement of the High-Boiling Petroleum Oils—II*

By the Action of Aluminum Chloride

By B. A. M. McAfee

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2090 Page 51, January 15. 1916

Oklahoma Crude Oil.—The residual oil from this crude (sp. gr. 34 deg. Bé.) by the usual process is a black, tarry mass, containing a large amount of asphaltic constituents and also paraffin. The amount of asphaltic constituents is so great, as a rule, that it is difficult to make paraffin and paraffin lubricating oils of the same grade as that obtained from Pennsylvania or Caddo residuums. By the aluminium chloride process (see Table III) this residual oil is cleaned of its asphaltic constituents, and paraffin wax and paraffin lubricating oils of excellent quality are made therefrom. At the same time, the yield of gasoline from the crude is greatly increased, at the expense of the less valuable fractions of the crude.

TABLE III.—TESTS ON OKLAHOMA CRUDE OIL (SP. GR. 34° BÉ).

Distilled to Free It from Moisture and Natural Gasoline.

YIELD FROM CRUDE OIL.

Primary distillate	Primary residual oil	Loss	Total Per cent
20.83	78.31	0.86	100.00

TESTS ON PRIMARY DISTILLATE.

Sp. gr. 54.1° Bé. Color W. W.

Distillation over 152° F.

Per cent	10	20	30	40	50
Up to	210°	226°	242°	252°	271°
Per cent	60	70	80	90	95 (dry point)
Up to	290°	313°	345°	408°	455° F.

Fractional Distillation.	Per Cent Charge.	Per Cent Crude.
Gasoline	70.00	14.58
Kerosene	20.00	4.17
Gas oil	7.50	1.56
Loss	2.50	0.52
Total	100.00	20.83

TESTS ON PRIMARY RESIDUAL OIL.

Color	Sp. gr.	Flash test	Fire test	Pour test
Black	29.8° Bé.	170° F.	205° F.	20

Distillation over 330° F.

Per cent	10	20	30	40	43 per cent
Up to	436°	484°	543°	590°	Below 600° F.

Mixture of primary residual oil and 5 per cent by weight of aluminium chloride was distilled during period of 48 hours. Temperature of the vapor line at the point of exit into final condenser was held around 350° F.

YIELD FROM $AlCl_3$ DISTILLATION OF PRIMARY DISTILLATE.

	Per Cent Charge.	Per Cent Crude.
Secondary distillate	64.61	50.60
Secondary residual oil	17.97	14.07
Loss	17.42	13.64
Total	100.00	78.31

TESTS ON SECONDARY DISTILLATE.

Sp. gr. 48.3° Bé.

Distillation over 140° F.

Per cent	10	20	30	40	50	60
Up to	225°	270°	294°	326°	358°	382°
Per cent	70	80	90	95	98 (dry point)	
Up to	413°	454°	503°	547°	570° F.	

FRACTIONAL DISTILLATION.

Fractions	Per cent Charge	Per cent Crude
Gasoline	40.00	20.24
Kerosene	50.00	25.30
Gas oil	7.50	3.80
Loss	2.50	1.26
Total	100.00	50.60

TESTS ON GASOLINE.

Color	W. W.
Odor	Sweet
Bromine No.	1.5
Dry test	O. K.
Heat test	2
Per cent S	0.027
Sp. gr.	64.5

Distillation of Gasoline Fraction—Over 130° F.

Per cent	10	20	30	40	50
Up to	160°	186°	200°	213°	222°
Sp. gr.	83.8	76.2	70.1	66.6	62.8
Per cent	60	70	80	90	Residue
Up to	238°	252°	270°	299°	8.3 per cent
Sp. gr.	60.4	58.5	56.1	53.3	48.2

TESTS ON SECONDARY RESIDUAL OIL.

Color	Sp. gr.	Pour test	Flash test
Red-green bloom	28.2° Bé.	90° F.	230° F.

Secondary Residual Oil Distilled.

Yield.	Per Cent Charge.	Per Cent Crude.
Wax stock	60.00	8.44
Cylinder oil	40.00	5.63
Total	100.00	14.07

SUMMARY

Products from $AlCl_3$ Process (Per Cent Crude Oil)

Distillate	Gasoline	Kerosene	Gas oil	Residual oil	Total
Primary	14.58	4.17	....	.....	83.72
Secondary	20.24	25.30	5.36	14.07	
Loss Due to:					
Aluminium chloride distillation				13.64	16.28
Working distillate into standard products				2.64	
Total					100.00

COMPARISON OF $AlCl_3$ PROCESS WITH USUAL PROCESS.

Per Cent of Crude Oil.	$AlCl_3$ Process.	Usual Process.
Gasoline	34.82	12.50
Kerosene	29.47	41.00
Gas oil	5.36	35.00
Residual oil	14.07	9.00
Sum of Products	83.72	97.50
Loss	16.28	2.50
Total	100.00	100.00

Although the crude petroleums from the various oil-producing districts in this country differ greatly in quality and in chemical composition, yet they are generally divided into three types: asphaltic-base crude, paraffin-base crude, and paraffin-asphaltic-base crude. The oils I have spoken of in this paper are representative of each of these types: Texas, asphaltic-base crude; Caddo, paraffin-base crude; and Oklahoma, paraffin-asphaltic-base crude. To give figures on other crudes would be merely a repetition of the results obtained on one of these. I shall, therefore, not take the time to give further examples. I might add that among the samples here are products made by the aluminium chloride process from 14 gravity California crude and 20 gravity Mexican crude.

RECOVERY OF ALUMINIUM CHLORIDE.

But all the good results of this process would be of no commercial value if the aluminium chloride could not be reclaimed. This chemical, when made on the ton scale, is not so expensive as it is when made on the pound scale, but nevertheless its cost is high, and from a dollars and cents view, it is necessary to recover it.

After a time, 48 hours or longer, aluminium chloride used in distilling oils, even the driest of oils, loses its catalytic activity and becomes converted into a coky mass. Analysis of the coky mass shows chlorine and aluminium present in the right proportions to form aluminium chloride, but the latter is, so to speak, masked. It does not display its ordinary reaction with petroleum hydrocarbons. The granular coky residue, after it comes from the oil-converting process, carries varying amounts of oils with it. If allowed to cool down in the presence of the body of oil, it may carry 40 to 50 per cent of its weight of oil. If the oil body has been separated while hot from the coky residue, the amount of oil will be reduced to 4 or 5 per cent.

After removing the oil, or the bulk of it, from the coky residue, the aluminium chloride can be extracted from the latter with water or steam to obtain a concentrated solution of hydrated aluminium chloride. Aluminium chloride in the hydrated state does not have the catalytic property of the anhydrous material, but the hydrated salt can be used as the raw material for making the anhydrous salt. To do this, advantage is taken of the property of hydrated aluminium chloride, breaking up when moderately heated to form aluminium oxide and hydrochloric acid gas. The alumina, when mixed with carbon and treated with hydrochloric acid vapors at a high temperature, reacts to form the anhydrous chloride, hydrogen and oxides of carbon. In utilizing this property, one portion of the hydrated chloride is heated to produce hydrochloric acid vapors and alumina, and these vapors on drying enter a further charge of alumina and carbon heated to redness. The hydrochloric acid vapors given off at a moderate temperature are thus utilized in further operations at high temperatures.

In another method of recovery, and the preferred one, the coky residue is heated to red heat in an atmosphere of chlorine which disengages the aluminium chloride from the carbon. Aluminium chloride volatilizes normally at a temperature around 365 deg. Fahr., but the coky residue may be heated to redness without much evolution of these vapors. If the heating is done in an atmosphere of chlorine, the aluminium chloride is unlocked, i. e., it vaporizes away from the carbon and is condensed in suitable receivers.

This account by no means covers the full scope of the aluminium chloride reaction with petroleum oils, yet to speak further would lead me outside of my subject.

* Read before the Seventh Semi-Annual Meeting of the American Institute of Chemical Engineers, San Francisco, August 25th, 1915.

By-Products of Gas Manufacture

Hydrocyanic Acid and Its Applications

ONE of the lesser by-products resulting from the distillation of coal is hydrocyanic acid, which is formed at high temperatures in the retort by the combination of hydrogen, nitrogen, and carbon. The amount of the compound occurring under normal conditions is, however, comparatively small, so that in the case of all but the largest gasworks recovery is rendered unprofitable by the cost of working the process. The cyanogen in coal gas is almost wholly present in the form of hydrocyanic acid, although some authorities state that it is also found as free cyanogen and ammonium cyanide. Whatever the form it may take, there is no question that it is essentially a high temperature product, and it seems probable that a portion of the ammonia is itself split up into its elements (hydrogen and nitrogen), which recombine with the addition of the carbon atom. Of the original nitrogen in coal it has been shown that less than 2 per cent goes to form cyanogen, the quantity of the latter considerably increasing when high and extreme temperatures of distillation are employed. The most favorable temperature in the retort for the formation of cyanide is said to be 2,200 deg. Fahr., and the maximum amount recoverable from a ton of English coal is about 1½ pounds of hydrocyanic acid, or about 10,000 grains. In addition to being found in the gas cyanide compounds also occur in the ammoniacal liquor (as ammonium ferrocyanide, etc.), in spent oxide (chiefly as Prussian blue), and in spent lime as calcium sulphocyanide.

USE IN GOLD EXTRACTION.

From a commercial point of view cyanogen derives its value from the fact that the principal method of treating rocks and quartz for the discovery of gold is by the well-known cyanide precipitation process, with or without amalgamation on copper plates. This consists of two essential operations: (*a*) Dissolving, by means of a specially prepared solution, the gold contained in the crushed ore; and (*b*) treating the cyanide solution so as to precipitate the gold in metallic form.

The mineral as won from the mines is primarily subjected to several sortings, and is then dealt with in large vats containing a solution of sodium, or occasionally potassium, cyanide. An extremely weak solution is usually employed owing to the fact that the greater the percentage strength of the cyanide, the more easily are metals other than gold dissolved. The length of treatment for dissolving generally varies between 12 and 24 hours, but in some cases the character of the mineral necessitates prolonged contact, and, under such conditions, the solution of cyanide should be renewed every three or four days. So far as the actual recovery of the gold is concerned, zinc is the most usual medium employed for bringing about precipitation. By adding the metal to the cyanide solution the gold is displaced, while the zinc takes its place in combination with the cyanide:

$$Na_2Au\,(CN)_2 + Zn = Na_2\,Zn\,(CN)_2 + Au.$$

The process, however, is not so simple as might be supposed from the above brief outline, and many modifications have been introduced from time to time with the object of rendering the working more economical and of increasing the efficiency of recovery. It may be mentioned that the cyanogen recovered from coal gas is not wholly employed in the gold industry, although nearly so. A small portion is made use of in the manufacture of dyes and paints, and also for electro-plating.

MODERN METHODS.

The chief processes in use in the gasworks of this country for the recovery of cyanogen are almost solely those in which the compound is recovered from the gas and not from the subsidiary products. In the most successful methods the cyanide is ultimately obtained either as ammonium sulphocyanide or as prussiate of soda (sodium ferrocyanide). Ultimately, of course, the sulphocyanide or prussiate is converted into sodium cyanide for the purpose of gold extraction; and, so far as this operation is concerned, recovery as the prussiate is to be preferred.

Although the extraction of cyanide as a distinct by-product will, in normal times, prove profitable only in the case of the larger gasworks, indirectly the removal of the compound from the gas presents many advantages; and if such compounds could be readily extracted and turned to profitable account the task of the gas engineer would certainly be made easier. Apart from the fouling of gasholder water, and the possible corrosion of gasholder plates and other apparatus, the removal of the cyanide is strongly to be urged owing to its effect on the efficiency of the purifying material. It is beyond all question that oxide of iron, whether natural or artificial, will remain in active condition for a much greater length of time when the cyanides are absent, so much so that both Bueb and Guillet have shown that in some cases the efficiency of the "dry" purifiers may be increased by 50 per cent if the compound is extracted. Perthuis, too, has pointed out that in certain circumstances cyanogen is responsible for a reaction—not wholly understood—in the purifiers which may cause the material in them actually to increase the sulphur impurities in the gas. On works where no recovery plant for cyanogen is in use the bulk of the substance will be removed by the oxide or lime purifiers, although some slight reduction will take place during the passage of the gas through the wet purification plant.

THE SULPHOCYANIDE PROCESS.

Hydrocyanic acid, although unable to combine with a simple solution of ammonium sulphide, will readily react with this salt when an excess of sulphur is present—i. e., with a solution of ammonium polysulphide. This fact, which remained unrecognized in the early days of cyanogen recovery, has had an important influence in the direction of simplifying the process from the gas engineer's point of view. Some two years ago, at a time when the Williams polysulphide process was first introduced, it became apparent that the working up of cyanogen could be accomplished on lines no more involved than those commonly adopted in the case of the more familiar by-products. Originally, advantage was taken of the fact that the ordinary gas liquor contains a large proportion of ammonium sulphide, and this was converted into the polysulphide by the addition of free sulphur in powdered form. In the newer process the necessity for introducing a special supply of free sulphur is avoided by making use of the sulphur in the spent oxide from the "dry" purifiers for the production of the polysulphides. The apparatus required consists merely of a rectangular cast-iron box about 20 feet square, access to which is obtained through portions of the top which are made removable on the lines of a Green's purifier. The inlet gas entering at the base of the vessel passes in the first instance through a tar extractor operated on the bubbling principle, the gas passing through the cyanide liquor which forms the seal. Above the tar extractor is arranged on suitable brackets a tier of ordinary wooden purifier grids which support a layer of spent oxide, spread evenly over the whole cross section of the vessel and about 24 inches in depth. The spent oxide used should preferably be of good quality, containing not less than 50 per cent of sulphur. It is maintained in a moist condition by a simple arrangement of sprays fitted round the four sides of the vessel at a point well above the oxide level. A short period of spraying every day with water or weak cyanide liquor is all that is necessary. In this way the polysulphide solution is formed within the interstices of the oxide bed, and is immediately converted into ammonium sulphocyanide by the incoming gas. The cyanide liquor, after trickling through the oxide mass, drops to the base of the vessel, from which it flows through a seal to the storage tank.

REACTION CONCERNED.

With regard to the actual formation of the sulphocyanide liquor it would seem that a straightforward reaction takes place on the following lines:

$(NH_4)_2S_2$ (ammonium polysulphide) $+ HCN =$
$(NH_4)SCN$ (ammonium sulphocyanide) $+$
$(NH_4)\,SH$

There is, however, some probability that a portion of the sulphocyanide is formed in two stages with the intermediate porduction of thiocyanic acid, as follows:

$(NH_4)\,S_2 + HCN = (NH_4)_2S + HSCN$ (thiocyanic acid).

The last-named then reacts with an additional quantity of ammonia, with the result that the sulphocyanide is formed:

$$HSCN + (NH_4)OH = (NH_4)SCN + H_2O$$

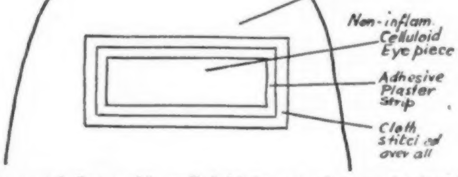
Perhaps the most surprising feature of the Williams process lies in the fact that although sulphur is inevitably required for the completion of the reaction, the spent oxide (after working for some considerable period) shows no tendency to lose its original sulphur content, while occasionally some increase is found. It would seem, then, that there is a simultaneous absorption of ammonia, sulphureted hydrogen, and oxygen, and that—as the oxide takes up sulphurreted hydrogen which is eventually oxidized to sulphur—a continuous supply of free sulphur is automatically provided. The process would, in fact, be continuous but that the physical condition of the spent oxide necessitates its periodical removal from the vessel and the substitution of a fresh layer. The period for which the material will remain in action varies under normal conditions between three and six months; thus, there is practically no labor attached to the operation of the process. Figures given by the inventor show that one ton of spent oxide is capable of dealing effectively with the whole of the cyanogen from 350 tons of coal, and one of the chief merits of the plant is the manner in which the ordinary duties of the washers, scrubbers, and dry purifiers are lightened. Of the total ammonia contained in the crude gas entering the plant an average of from 30 to 35 per cent is absorbed, the sulphureted hydrogen shows a reduction of 35 per cent, and carbonic acid falls off by from 5 to 12 per cent. No claim can be made for the absorption of carbon disulphide. It must be borne in mind, however, that a small proportion of oxygen entering with the inlet gas is essential. In general, this proportion varies between 0.2 and 0.6 per cent; and, by oxidizing the iron sulphide in the purifier, it gives rise to the free sulphur which is vital to the effective working of the process. The cyanide liquor flowing from the plant varies in strength from 2½ pounds to 3 pounds of ammonium sulphocyanide per gallon, and (after conversion to calcium sulphocyanide) it may be concentrated to any desired strength.

CONVERSION INTO AMMONIA.

Although the hydrocyanic acid may now be recovered by the exceedingly simple means described above, universal extraction throughout the gasworks of the country is not altogether possible owing to the somewhat limited demand for the product. For this reason renewed attempts have been made to overcome the market difficulty by converting the ammonium sulphocyanide directly into ammonia, for which there is invariably a steady demand. The method by means of which this transformation may be effected was fully described in the *Engineering Supplement* of February 18th, 1914, at the time of its inception, but it is doubtful whether at the present moment its adoption would be permitted.—*Mechanical Edition of the London Times.*

Anti-chlor. Respirators

THE respirators used by British soldiers who have the risk of going into atmosphere poisoned by Germans with chlorine are saturated with a solution of sodium hyposulphite and sodium carbonate. The following is a diagrammatic sketch of a hood which is being much used:



As non-inflammable celluloid is not always obtainable, transparent, insoluble and non-inflammable gelatin is also used. The hoods, with the insertion for the eyes, are saturated with the following solution by means of a powerful spray; they are then packed in waterproof tissue to retain their moisture as long as possible, though the War Office says that it is not essential if water is at hand; *it must be moist to be efficient, the nose and mouth being covered.* The eyepiece is first stitched in, then adhesive plaster placed over it.

Sodium hyposulphite	15 oz.
Sodium carbonate	5 oz.
Glycerin (by weight)	2 oz.
Water	10 oz.

Mix the glycerin and water, and dissolve the salts in the mixture, straining if necessary.

A little eucalyptus essence may be added to the solution as a refresher. About 6 fluid drams of the solution is used for each respirator.

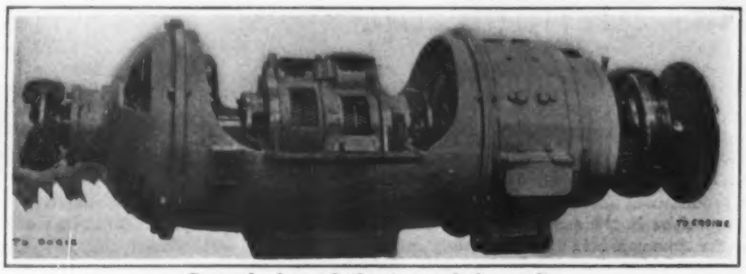
The main reaction is represented in the following equation:

$$4Cl_2 + Na_2S_2O_3 5H_2O + 5Na_2CO_3$$
$$= 2Na_2SO_4 + 8NaCl + 5H_2O + 5CO_2$$

There are secondary reactions, but it will be seen that the chlorine is fixed as sodium chloride.—*The Chemist and Druggist, London.*

When the Railroad Lost Business

ONE of the economics practised in England, where distances are short, is to return to the shipper all crates, casks and other large containers in which goods have been packed. The freight rates paid on this "returned empty" business are very low, and probably for this reason some of the roads apparently have not appreciated its value, and consequently have made arbitrary regulations in regard to handling such shipments. As a result firms in one district who receive goods are handling their "empties" over to other firms who have goods to ship, and the railroad finds that it has killed what was a paying business.



General view of the transmission unit.

Chassis of a light car, with power plant.

An Ingenious Electric Drive Gear

Adapted for Light Railway Work

THE good use of the internal combustion engine for self-propelled cars or locomotives is a leading question just at present, especially for suburban work or for light railways where traffic is to be handled without too great cost of installing the lines. In many cases electric trains are preferred to steam on account of their absence of noise, smoke and dirt, but it is only lines carrying a large amount of traffic that will stand the heavy expense of putting in electric roads. For smaller roads, which are now on the increase, the gasoline locomotive or car is expected to fill the need, and there is already a considerable progress in this direction. We already possess light engines of high power which run upon cheap grades of oil, but the suitable means of transmitting the power from engine to car wheels has not received so much attention.

The new Thomas transmission method, of English invention, is claimed to supply what is needed as the best way of connecting up engine to car wheels, and this without a troublesome change-gear box. It is partly mechanical and partly electrical, but differs completely from what is commonly known as "gasoline electric" system, for there is a direct mechanical drive from engine to car wheels when running at top speed, and the electric devices only come in at the slower speeds, or for starting up the engine. The works have just completed a 200 horse-power coach on this principle for the New Zealand government railways, and it is to be used mainly on suburban lines on account of its clean running, taking one or more trailers.

As to general layout, it uses a long truck with double Midland bogie, and carrying near the middle the 200 horse-power Tylor gasoline engine. On one side of the engine is the combined mechanical and electrical transmission (see photograph), which lies in the axis of the car and connects on one side with engine shaft and on the other side a rod coupling of automobile type that runs to one of the axles of the bogie for mechanical drive upon this bogie. On the other side of the engine, but disconnected from it, is an electric motor which couples to a rod transmission going to the bogie axle on that side. The first bogie is thus driven through the combination device, and the second bogie by the electric motor.

Turning to the principle of the combination device, the main shaft of the motor *A* is permanently connected to the casing *B* of the planetary gearing, and this casing carries a set of two planet wheels on two spindles which run in roller bearings. Each spindle has rigidly fixed to it two planet wheels of different diameters, and these in turn are in mesh with the two sun wheels. The larger sun wheel drives the outside axle of one bogie by means of the magnetic clutch *E* and the driving shaft *D*. Final drive to the car axle is effected by a bevel and spur reduction gear set. The smaller sun wheel is connected direct to the armature of the first electric machine *C*, and a second magnetic clutch *F* is provided for locking the planetary gearing. A second electric machine *G* is located on the opposite side of the engine and drives the outside axle of the second bogie by means of a Cardan shaft and a bevel gear reduction, as in the case of the first bogie.

To start up the engine, the clutch *E* is disengaged and the clutch *F* engaged. This locks the gearing, and the first electrical machine *C* is thus locked solid with the engine, so that when the battery provided for the purpose is connected upon the electric machine *C*, it acts as a motor and starts up the engine. In order to understand the action of the gearing, let it be assumed that both clutches are disengaged. When the engine drives the casing *B*, a differential action is set up between the large sun wheel and the small sun wheel. The large sun wheel tends to rotate forward in the same direction as the engine, and the small sun wheel tends to rotate backward in the opposite direction to the engine. If the clutch *E* is engaged, then the large sun wheel will be held stationary, as it is direct connected to the load, or to the axle of the car, and as the small sun wheel is free, it will rotate backward at about the same speed as the engine rotates forward. If current is taken from the electric machine *C*, which now acts as a dynamo, the motion of the small sun wheel will be retarded, so that the large sun wheel, i. e., the load, must begin to move. By manipulation of the field of the machine *C*, this action can be continued until the small sun wheel is practically brought to rest, and the large sun wheel caused to rotate at about half engine speed.

During this initial period, the current from the machine *C* is transmitted to the second electric machine *G*, which acts as a motor and drives the second bogie of the car. The next operation is to gradually increase the speed of the large sun wheel until it reaches the engine speed, so that the gearing can be locked solid by the clutch *F*, and a direct drive obtained for top speed. This speeding up of the large sun wheel from half speed to top speed is obtained by changing the functions of the two electric machines, and causing *G* to act as a generator and supply current to *C* as a motor, driving the latter in the same direction as the engine. This operation is a gradual one, and is carried out by manipulation of the field of machine *G*. When the sun wheels and the casing have reached a common speed, the magnetic clutch *F* is engaged, so that the electrical transmission is cut out altogether and a direct drive obtained from the engine to the first bogie.

When the car is traveling on top speed, the two electric machines *C* and *G* are not in use, and can be employed for producing current. It is convenient at this stage to use them for charging the battery which is used for starting the engine and lighting the vehicle. It must be pointed out that this battery is never used at any time for assisting in the propulsion of the car. As the vehicle has to travel equally well in either direction, it is required to use a reversible gasoline engine, but for shunting and reversing for very short distance, an emergency reverse is provided, which works in the following manner. The clutch *E* is disengaged and clutch *F* engaged, so that the machine *C* is locked solid with the engine. Current is then taken from this machine as a generator to supply the second machine *G*, acting as a motor with a reversed field, and the car is driven exclusively by the second electric motor, in the reverse direction.

The engine is an 8-cylinder Tylor "V" type, 7-inch bore and 8-inch stroke, 900 revolutions per minute normal, or 1,500 revolutions per minute maximum, and is designed with reverse gear. At each end of the car is mounted a radiator, using turbine water pumps. Controlling cabins are situated at the ends of the car, to handle the electric circuits, including the magnetic clutches.

As to the advantages of the Thomas system, it is to be noticed that the engine is only running and consuming fuel when it does useful work. It is estimated that the fuel consumption will be on the order of 200 ton-miles per gallon of gasoline. On the South African railways it was run upon the line from Johannesburg to Witbank (91 miles) at a maximum speed of 45 miles an hour, and here the consumption was 228 ton-miles per gallon. Severe work can be had on a make up of this kind, and it is specified to carry passengers and haul a 25-ton trailer up a grade of 1 in 40 at 15 miles an hour, the gross load being about 60 tons. The coach will seat fifty passengers. With the Thomas system the engine can always be kept running at the most suitable and efficient speed. The absence of change-gear box, which we mentioned, is an interesting point, there being no shocks, and the car is easy to drive. Still another advantage is had in a good self-starting and also an electric lighting equipment with practically no extra cost. We should mention that the system has also been used on motor wagons, and one of these won the Royal Automobile Club trophy on a 2,000-mile test. Such cars are also made up for military use.

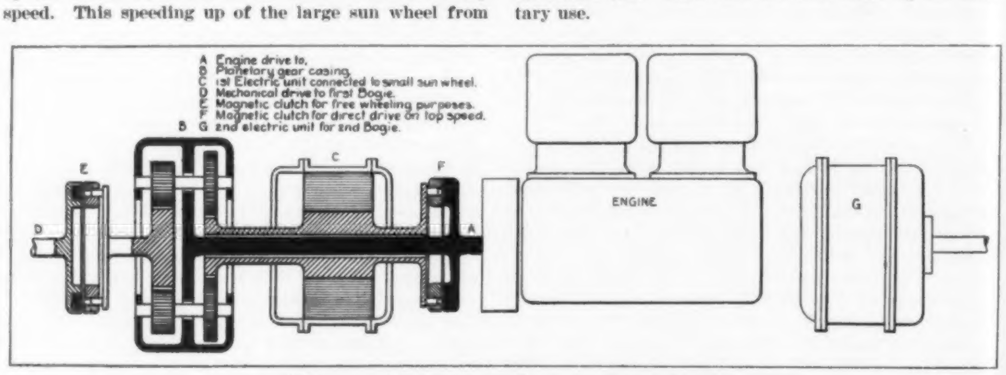


Diagram showing general arrangement of parts.

Patient or "Case"?

"I AM a *human being*, not only a *case!*" exclaimed a little woman in a New York hospital recently, thus arresting and impressing the attention of the young physician in attendance, who adjusted his thinking cap and set about comparing notes with his confreres, some of whom, he discovered, had met with similar experiences and found it necessary—as well as helpful and profitable—to take into consideration the human element in its relation to what they routinely had considered merely "*cases*."

In the amphitheater and in the laboratory we acquire the science of medicine, but in the school of experience alone do we learn its art; that is, in its practical application to individuals, which is a very different matter from the study of cases without regard to temperamental differences and personal idiosyncrasies. Sooner or later every physician discovers that these two important factors make every case different in reality from every other case—each, in brief, a "law unto itself." The human element immediately becomes the essential fact to be thoroughly studied and understood if success is to be achieved—success arising from the actual results obtained by medical skill, the genuine art of medicine. That these matters should receive more attention in the training of young physicians goes without saying, especially in regard to individualization in treatment—the exaltation of the "patient" above the "case."—*American Medicine.*

Autobus in Spain.

ACCORDING to late reports there are numerous public automobile services now in operation in Spain, the number reaching as high as 103 different lines. The number of cars is not given. The total length of routes is said to be as much as 3,100 miles, and has no doubt increased since the reports cited. There are a certain number of automobiles also used in the Canaries, and out of 100 officially registered cars there are 18 of these listed. Among the cities which have a public service are Barcelona and Salamanca.

Zeppelin Airships*

An Address, Historical and Descriptive, by Their Designer

Every development begins with the inception of the idea. The great value of airships traveling in safety over long distances and with useful loads, I was led to see through an article published in 1874, by Secretary Stephan, of the Imperial Post Office, on "International mail and airship travel." That awakened in me the desire to make such ships a reality.

The few motor airships that had flown up to that time—of which the best was the military airship "La France"—could hardly be regarded as models because of their slight accomplishment. The airship of the Austrian engineer Schwarz was quite unknown to me at the time mine was being planned. But from the very beginning it was clear to me that in contrast to water navigation, in which a tree-trunk used as a raft was a useful vehicle even for primitive man, the very first airship which could have any promise for the future must have very great length over all.

The following means were at my disposal for lifting a weight into the air: Air rarefied by heat, and the light but very inflammable gas hydrogen. The former was impossible because of the great weight of the fuel necessary to maintain the heat, so hydrogen alone remained.

I have often been reproached for building airships in which so inflammable a gas had to be used. But since, after several thousand trips of my airships, only one has been burned in the air—and that due to an unfortunate co-incidence which can be avoided in the future—no one can claim that the danger has been so great as to have warranted my giving up the undertaking.

The "Schwaben," a Zeppelin airship of the rigid frame type.

The gas cells I planned to make of silk, covered on both sides with gold beater's skin, or even of gold beater's skin itself. But as no means of keeping this material pliable was at that time known, I took gummed water-proof cotton cloth which, with the "Ballonin" invented by Duttenhofer and Liwentaal, was used to make the cells gas-tight.

It was difficult to decide whether I should build of wood, steel, or aluminium. Only after long experimenting under the supervision of Prof. (now Councilor) von Bach in Stuttgart, I decided upon aluminium as the building material, since the latter with equal stiffness, was appreciably lighter than wood. Steel was not even considered, because the necessary stiffness could not be secured by sheet metal, which was too thin to be grasped on the edges, and could not be firmly riveted, while the use of stronger sheet metal would give too great weight.

Pietzker, the marine architect, who met a tragic end with his ship "L2," wrote shortly before his death, for the Society of Shipbuilders Technique, an ingenious article on the relations between ship-building and airship building, which testifies to the clear insight and the thoroughness with which he had penetrated the principles of ship-architecture. In Pietzker's article occurs the following: "One of the chief difficulties of ship-architecture as compared with all other fields of building technique, is that our greatest efforts must be directed toward lightness of weight. And we have made great fields of technical construction subservient to this." But what does that signify under conditions where a cubic meter gives only a thousandth part of the lifting force. In water a cubic meter will float 1,000 kilogrammes; in the air, 1 kilogramme.

This slight buoyancy of the air forced me at the very beginning to build in such enormous size that I foresaw the doubts that would arise as to my sanity. In order to prove the correctness of my theory, my first airship had to be able to lift its own weight, fuel and oils for several hours, water for ballast, different apparatus, cable, anchor appliances, etc.; besides that, a motor that would attain at least a speed of 9 meters per second, and, of course, the necessary crew. For further security against failure an excess of buoyancy had to be allowed for things that might be forgotten or for additions. For all this a volume of gas equal to 11,300 cm. was required.

The jacket for the metal framework, the outer covering, consisted of water-tight cotton cloth above, and thin silk below, because of its greater lightness. For power I chose the Daimler motor, comparatively light and at that time the most reliable. It weighed 30 kilogrammes per horsepower, and it required 500 grams of benzine, per brake-horse per hour. A 9 horsepower motor in a 10 hour-flight required 200 liters of cooling water. In order to determine this last, as nothing was known about it at the time, I let the water which had become heated run into an upper shallow vessel from which it dripped into a lower vessel through numerous little holes, and from this it was conducted back into the motor after cooling. For use in the airship the water to be cooled flowed through long pipes fitted with spined rings so that the temperature was kept down by artificial surface cooling of the air. This arrangement was succeeded in the second or third airship by the cooling apparatus invented in France, which in improved form is still in use.

In order not to get too wide and therefore too heavy a gearing, and in general not to get too great width for the airship, 4 bladed propellers of 1.15 meters diameter were chosen, which, in spite of the necessarily hasty construction, are said to have reached an efficiency of 71.3 per cent.

The volume of the airship once fixed, the form was evolved from the practical relation between smallest area in order to attain least weight, and smallest cross-section in order to keep the resistance low. Certain considerations regarding the handling of the airship on the ground, as well as the size of the building shed, allowed at first a diameter of only 11.6 meters for the gas envelope, and this led finally to a length of 128 meters, 11.03 times the diameter.

It seemed impossible to keep this enormously extended figure firm by merely pressure from within, and so the rigid skeleton suggested itself. But even then the weight could not be concentrated under the center; for the greater the beam, which we may think of as represented by the gas envelope, the stronger it must be; and there we come to a definite limit of length, where the weight of the structure becomes greater than the buoyancy attained by the increased amount of gas. Therefore I divided the main weights: the motors and the cars, into 2 parts, putting one under the center of buoyancy of the front end and one under the center of buoyancy of the rear end. From these considerations, calculations and building elements, the first completed airship was produced in 1900, with the following dimensions:

Diameter	11.6 meters.
Length	128.0 meters.
Midship cross-section	106.0 sq. m.
Contents	11,300.0 cu. m.

The ends were alike, 16 meters long.

A cross section of the skeleton is a polygon of 24 sides. It is built in open basket work consisting of longitudinal girders and partition walls. Spaces between the walls were 8 and 4 meters, by which the whole space intended for gas is divided into 17 parts. The aluminium used for building has a specific gravity of 2.7, and a tensile strength of about 33 kilogrammes to the square millimeter. With it are built flat lattice girders of angle and T sections, the paneling also being of angle metal. The weight of these girders varies according to their use, from 0.90 to 1.8 kilogramme to the meter, and the weight of the whole frame is 5,825 kilogrammes, or 0.516 kilogramme to the cubic meter.

Corresponding to the number of divisions, the airship contained 17 gas cells of water-proofed cotton cloth, which in the upper half of the ship weighed 0.170 kilogramme to the square meter and in the lower, because not so thickly gummed, 0.150 kilogramme to the square meter. The outer covering had, above, a weight of 0.130 kilogramme to the square meter, below, 0.085, making an average of 107 kilogrammes to the square meter.

While the horizontal steering was accomplished by rudders formed of wooden frames with cloth stretched over them under both ends, the vertical steering was done by means of a low hanging sliding weight at first, later by a sliding weight rolling in the gangway. But as early as the third ascent a plane was attached under the front end, and thereby for vertical steering as well as for all other functions in driving an airship the possibility of greater security was doubled.

In each of the two cars suspended rigidly between the first and second quarters of the length, and the third and fourth quarters, there was a 14.7 horse-power Daimler motor.

By means of a double bevel pinion of cast aluminium and rawhide, the two motors drove each two screws, attached at the height of center of resistance, to the right and left of the supporting frame. The mechanical parts had a total weight of 1970 kilogrammes or 67 kilogrammes per horse-power.

This first rigid airship, with all its weak points and its shortcomings, laid the foundation for the development of the rigid system.

Comparison with the newest ships will demonstrate the degree of perfection that has already been attained; then we can look further and see what development the rigid airship is still capable of.

Once a dirigible flying ship had been built, it was a question of shaping it into a vessel usable for the purposes of trade and of war.

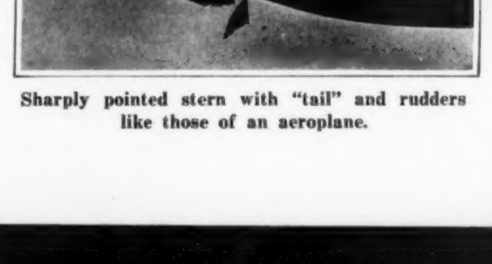
Greater lifting power was necessary first of all for carrying stronger engines for faster flights, and more fuel for longer flights; likewise, the carrying of a greater number of passengers, of larger quarters, of ignition cells, of anchor apparatus, and of spare parts.

Lighter gas to increase the buoyancy did not exist, nor at that time was there any lighter building material to decrease the weight. On the contrary, the weight of the earlier gas-cells had to be increased from 170 kilogrammes per square meter to 230, until at last the proper treatment of gold beater's skin was discovered, and the weight of the cells brought back thereby to 170. Imperviousness has been brought to a nearly perfect state. The weight of the outer covering was increased because in the first ship the silk used for the lower half proved too thin and too elastic, so that cotton had to be substituted.

As a means of increasing the carrying power there remained only the increase of size of the gas envelope and a more sparing use of aluminium. The increase of gas space is limited by the difficulty of handling the monsters and of constructing sheds for them.

The introduction of a skeleton triangular girder in place of the plane, as well as the general use of stamped parts, indicated a greatly increased tendency to make the most of the material.

The significant gain in buoyancy, brought about mainly by increase in volume, made it possible now to



Sharply pointed stern with "tail" and rudders like those of an aeroplane.

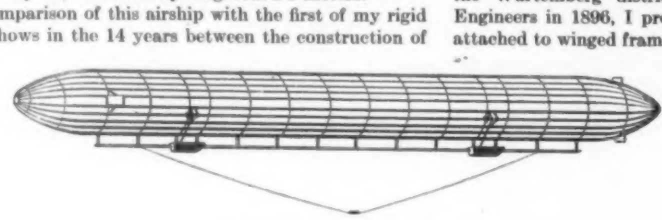
* *Yahrbuch der Schiffbautechrische Gesellschaft.*

proceed to increase the speed. The accomplishment of this is due more than to anything else to automobile construction, which is constantly calling forth better, more reliable and stronger motors. It has made it very hard for the development of air navigation, that it is not worth while to the builders of motors to devote sufficient time and money to the production of machines especially adopted to the purpose by their reliability in working, easy accessibility and light weight per horsepower. There was nothing to do but to turn to the manufacture of motors, and here the greatest success was won by the type devised and gradually perfected by Messrs. Maybach, father and son.

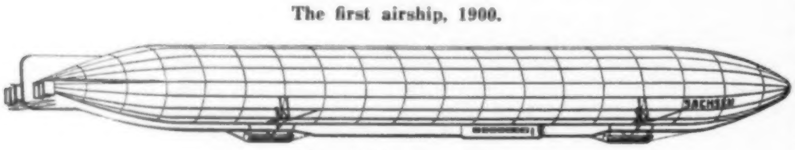
Some progress could now be made in the construction of slender ends in order to lessen the resistance due to the shape, although in so doing a less favorable relation held between content and surface.

The most important innovations made possible by the increase in buoyancy were the introduction of a third motor, a wireless station, comfortable quarters, gangways through the supporting frame to upper decks, putting in of searchlights, etc. So we arrived gradually at the airships of to-day, represented by the "Sachsen" built last year, and recently lengthened 8 meters.

A comparison of this airship with the first of my rigid ships shows in the 14 years between the construction of the two, a progress equal to that in steamship navigation in the last century. The diameter has increased from 11.6 to 14.8 meters; the length from 128 to 145 meters; the length being now 10 times the diameter, where formerly it was 11 times; the contents 20,800 cubic meters against a former 11,300, an increase of 9,500 cubic meters, which, varying with barometer and temperature, will mean an increase of lifting power from 9,000 to 11,000 kilogrammes. The 24-angle cross-section has now become a 17 angle. The front and blunter end is now 28 meters long and the slenderer one at the stern 32 meters. The "Sachsen" has 17 compartments. The style and material have remained the same.



The first airship, 1900.



The "Sachsen," 1914.

What vastly greater strength is possessed by the new forms of lattice girders, in spite of the mean decrease of 0.13 kilogramme weight to the meter, can be seen from the fact that the skeleton of the first ship, even in comparatively slight bending movements, showed great changes of form (as high as 25 centimeters); on the other hand no such changes have been observed in the new ships from these causes. Corresponding to the vastly greater strength, the weight of the skeleton has been kept relatively lower.

The gradual improvements just described have been accompanied by corresponding progress in the accomplishments of airships. There were so many small defects in the first airship—such for example as the fouling of a rudder, the accidental opening of a ventilator, etc.—that it could barely show a speed of 9 meters per second, and could carry fuel for only about 10 hours' trip. But with the second ship a speed of 12 meters per second was shown, and the fifth made a 38-hour trip of 1,194 kilometers, ending in a pear tree near Göppingen, not because of any fault in the ship—there was still provision enough for several hours and the two motors were in the best of order—but because the crew was exhausted. Meantime several thousand trips with Zeppelins have been made under the most varied and often the most difficult conditions. These prove that the mathematically definable results are actually accomplished by the airships.

And now the "Sachsen"! At a speed of 72 kilometers per hour, and carrying 1,000 kilogramme crew and 3,000 kilogramme freight, it covers a distance of 2,200 kilometers; and even with an adverse wind, which would have prevented the first ship from moving, it has covered a distance of 1,480 kilometers. The more economically it uses its driving power, that is, the more slowly it goes, the longer is the distance it can cover. On a flight with half power, the distance is increased to 2,900 kilometers. And if the "Sachsen" could and would travel with the speed with which the first ship traveled 1,800 kilometers, it would amount to a really great distance, namely, 30,000 kilometers. There would, of course, be no value attaching to trips that were slow with a favorable wind or unsafe with adverse winds. If airships are to find practical use for purposes of trade, they must be able to cover definite distances even in unfavorable weather, with a paying load of passengers, mail, etc., and be able to do this more rapidly, more comfortably, and at least as safely as any means of transportation by land or water. One would be justified in assuming from past experience that as soon as revolving sheds are possible, the limit of distance for airships of the "Sachsen" class would be about 1,000 kilometers. So even with the airship of to-day a regular paying traffic could be carried on between Berlin and London or Stockholm; between Stockholm and Petersburg, Constantinople and Alexandria, Genoa and Algiers, etc., as soon as the public had gotten used to the idea that one cannot travel more comfortably, more free from sea-sickness, more rapidly, or with less danger.

But the present attainments represent only one step of the development which I planned from the beginning for navigation of the air. Only when trips, which take weeks by other means of transportation, can be made safely and with paying freight, will the goal be reached.

But, shall I hold to may purpose? In a lecture before the Wurtemberg district of the Society of German Engineers in 1896, I prophesied that a motor could be attached to winged frame for flight, whereby the foundation would be laid for traveling with flying machines ever increasing in size—and today, only 18 years later, I, with all the rest of the aviation world have had to ask myself whether the flying machines would not take over the tasks of my airships, produced in the meantime, and rob the latter of their *raison d'être*.

I could not be satisfied with a denial of this, arrived at by way of my own reasoning, and as I have always done, I turned to science to prove the correctness of my conclusions. My associate, Engineer Dornier, has, on the basis of his exhaustive investigations, sketched a picture of the further possibilities of development, and, thereby, as far as possible, compared the efficiency of motor airships and flying machines.

Following Count Zeppelin came C. Dornier, Dipl. Eng., whose consideration of the subject was purely along mathematical lines. His purpose was to compute the efficiency of the airship under various theoretical conditions, to forecast in a measure the possibilities of the future and to make some comparisons between the airship and the aeroplane. He first undertook to establish what he termed the fundamental equation of motor airships, and in the determination of this he took into account a number of factors, including the available gas space, the lifting power of the gas, the empty weight of the ship and weight of its equipment. The empty weight includes the weight of the frames, gas cells, outer covers, the rudders and compensating planes, the cars and other apparatus and furnishings. The total weight of the gas cells is affected by their number.

The weight of the skeleton depends, with given dimensions, upon the strength necessary to withstand the forces attacking the body of the ship. The weight of the equipment is the sum of those of the motors and appurtenances, the tanks, driving gear and propellors, etc. From these factors and those expressing the resistance of the air, the fundamental equation is derived.

With this determined a number of methods of treatment are possible. Subtracting from the lifting power the empty weight plus the weight of the machinery plus the weight of the supplies, one arrives at the capacity for freight, which may, of course, include either passengers or freight, or both.

With the fundamental equation established in algebraic form, Mr. Dornier considered first, whether it may be possible to raise the standard of efficiency in rigid airships without an increase in gas space.

One phase of this question is, however, quickly to be settled, for it is evident that such a thing is possible only by making use of some lighter gas. Even in the case of the vacuum, which is most favorable of all, since there is absence in it of any weight, only 7 per cent increase in lifting power would be realized. There is no help here toward increasing the freight carrying capacity with the same quantity of gas. The empty weight of the ship also can under present circumstances be varied but little.

The speaker next turned to the possibility of increasing efficiency by decreasing the resistance to flight. This may be done by making the form of the ship more favorable, by diminishing unfavorable resistance or by reducing the friction. How important this would be was shown graphically, and, assuming that the resistance were reduced no more than 3 per cent, the carrying power of the improved type compared with those of the "Sachsen" type at different speeds would be these:

Speed, Kilometers, per Hour.	Capacity, Improved Type.	Capacity, "Sachsen" Type.
54	4100 kilogrammes.	3400 kilogrammes.
63	3000 kilogrammes.	2200 kilogrammes.
72	1700 kilogrammes.	770 kilogrammes.
81	200 kilogrammes.	0 kilogrammes.

The figures show the importance of diminishing flight resistance.

In considering the efficiency of the machinery, Mr. Dornier finds that it is already pretty satisfactory. There should be some improvement in the propellors, in which the efficiency is now about 65 to 70. Then again the motor industry can hardly fail to afford improvements. In order to get at the value or possible value of increased efficiency here, a computation is carried on assuming an increase of about one-seventh in efficiency of machinery, the results of which are here given:

Speed, Kilometers, Per Hour.	Capacity, Improved Efficiency.	Capacity, "Sachsen" Efficiency.
54	8750 kilometers.	4500 kilometers.
63	6450 kilometers.	3300 kilometers.
72	4850 kilometers.	2500 kilometers.
81	3800 kilometers.	2000 kilometers.

The efficiency is expressed in distance traveled with a 3,000-kilogramme load.

Turning now to the question of the value of increasing dimensions of airships Mr. Dornier presents considerations on a group of ships similar to those now in use, in which the ratio of diameter to length is 1 to 10. The outer form of the ship is assumed to be similar to those of to-day. On the basis of experience with ships from 11 to 16.6 meters in diameter, and with models, he believes it is reasonable to compute the efficiency of airships even up to 30 meters diameter and 300 meters length. The fundamental figures are of interest, and these are given as follows: buoyancy, 1.1 kilogramme per cubic meter; efficiency of machinery, 0.70 (the present figure); weight, 6 kilogrammes per horse-power; and consumption of fuel, 24 kilogrammes per horse-power hour.

Some examples were noted to show the effect upon efficiency of increasing the diameter (and other measurements proportionately) of airships.

(1). Given the distance or time and speed, to find the freight for individual ships. The calculation for this example arrives at these interesting results:

Dia. in meters...	18	20	22	25	30
Freight capacity in kilogrammes.	600	3400	7300	25,200	33,300

The increase in diameter from 18 meters to 30 makes the carrying capacity 55 times greater.

(2). Given freight and speed to find time and distance of ships of different types, the following figures express the answer:

Diameter in meters.....	20	22	25.0	30.0
Time in hours.........	10	23	39.5	57.5
Distance in kilometers..	900	2070	3660.0	5180.0

The time indicates the length of flight in hours as the distance does in kilometers. And the interesting part of the computation is that with equal freights (the loads for all the ships being assumed at 15,000 kilogrammes) the big ship travels faster than the smaller one.

Some of the expositions of Mr. Dornier assume an increased efficiency of the machinery which more than doubles the capacity for freight with slight improvement in efficiency (about 10 per cent).

Meeting the argument that with increase of dimensions there come greater initial cost and expenses of up-keep, it appears that when these are reckoned in percentage of freight capacity, the big ship has the advantage over the small one. On the whole, increase in volume of the airship, perfection of machinery and decrease of resistance go hand in hand, and one may well say that the motor airship is not at the end, but at the beginning of its development.

For the concluding section of his paper Mr. Dornier made some comparisons between the flying machines and the airships. Messrs. Bendemann and Everling of the German Experiment Station in Adlershop, give an equation of the work of the flying machine (in No. 8, of the *Zeuschrift fur Flugtechnik und Motorluftschiff-Fahrt* which is comparable to that developed by Mr. Dornier for the airship. Based on this equation the opinion seems justified that there are limitations of distance for the flying machines. The freight carrying conditions seem about the same. With the increase in freight, however, the flying machines must increase rapidly in size, and the efficiency required keeps pace with this, so that the advantage of easy handling is likely to be lost by the flying machines when several thousand kilogrammes of freight are to be carried.

So long as it is a question of great distances and moderate speed comparatively speaking, the motor-airship is to be preferred to the flying machine. If, on the other hand, it is a question of short distances with very great speed, the flying machine is greatly superior to the airship. At 90 kilometers per hour the lines of the two kinds of aircraft cross and at 108 kilometers an hour, the airship can no longer keep pace with the flying machine.

In order to prevent misapprehension, it is pointed out that the figures given do not represent absolute practical values, but are of interest for the comparisons which they afford.

Dr. Zeppelin again took up the discussion that these explanations open an amazing outlook into the future. Of course, the theoretical distances must suffer appreciable limitations from accelerating or retarding currents of air. For in reality only those distances can be attained which an airship can cover by its own motion in spite of adverse winds. With the narrow swift flying aeroplane the currents of air play a much more subordinate role than with airships which fly very far and very slowly.

In spite of these limitations this fixed law has been established for both kinds of air-craft, that quite independently of the freight to be carried, the flying machine must arrive at its goal considerably earlier than the airship. For the former needs a mechanical apparatus powerful enough to control the start, and must make comparatively generous use of it during the whole trip in order not to sink; therefore it cannot prolong the time of flying at will by economical treatment of fuel. This on the other hand is to a very high degree possible with airships, which, like balloons, can rise and remain suspended without machinery. Flying machines are accordingly, even for their safety, much more dependent upon the good condition of their machinery than airships—for example, that no propeller blade break, and no motor quite gives out. For comparatively short trips on the other hand—up to 1,000 kilometers when it is necessary to make them in the shortest possible time—they will always be superior to airships because of their greater velocity. They have the further advantage that their ability to fly is not affected by the altitude.

But, if it is a question of distances of 3,000 kilometers and over, where no stopping places can be established—*e.g.*, across the Atlantic or from the heart of Europe to Colombo or between China and Japan and the like, then begins the reign of the airship for uncounted ages. May our generation be great enough, in spite of the truly amazing progress of the flying machine, to give unswervingly to airships the development which will fit them for the conquest of their great field.

At the beginning of my remarks, I spoke of the danger of inflammable hydrogen. The finding of a non-inflammable gas, even if it were not quite so light, is not impossible. For this reason the gradual development of airships to such sizes that they would be carried by non-inflammable gases must not be neglected, for thereby the very safest vehicle conceivable would be procured.

Oil-Mixed Portland Cement Concrete—I*

Notes on the Preparation and Use of a Valuable Building Material.

The enormous growth of the American Portland cement industry, with its production of 22,342,973 barrels of cement in 1903 and 92,949,102 barrels in 1913, is striking evidence of the widespread use of this deservedly popular material of construction. Combined with sand and stone or gravel in the correct proportions and mixed with the proper amount of water, the resultant product—concrete—is a structural material of perhaps more universal adaptation than any other material now in use. Its application to foundations for heavy machinery, to dams, walls, bridge piers, tunnels, subways and building blocks, is well known. When properly reinforced with steel, its use is even more widely extended to the construction of bridges, vats, sewers, water conduits and numerous other classes of construction.

The farmer has found concrete to be of material benefit to him in building various farm structures, which were formerly made of more perishable materials. Thus, when reinforced with steel wire or rods, fence posts may be made with an interminable life and at very low cost. It is also exceedingly well adapted to the construction of water tanks, cisterns, silos, pavements, floors, buildings, feeding troughs, etc. Simplicity and ease of manufacture and of manipulation in construction work, strength and durability, and comparatively low cost are some of the considerations which render its application so universal.

In spite, however, of the many virtues possessed by concrete as a material of construction, faults are apparent in its tendency to crack, owing to external temperature changes, to the rise and subsequent fall of internal temperature while it is hardening, and to the shrinkage which accompanies the drying out of the mass. Then, too, as ordinarily made, concrete is more or less porous and absorbent of moisture—characteristics of the material which are plainly evident in the damp appearance of concrete houses after a period of wet weather, in leaky basement walls and floors, and in reservoirs which persist in losing water.

If concrete could be made less absorbent of moisture and less porous, its ability to withstand the penetration of water would be greatly increased, and the material would then be a much more desirable one for structures in which it is now used with only partial success.

OIL-MIXED CONCRETE.

While experimenting in the Office of Public Roads in an attempt to develop a non-absorbent, resilient and dustless road material, one capable of withstanding the severe shearing and raveling action of automobile traffic, the writer's investigations led him into a very promising discovery. He found that when a heavy mineral residual oil was mixed with Portland cement paste it entirely disappeared in the mixture, and, furthermore, did not separate from the other ingredients after the cement had become hard. The possibilities of oil-cement mixtures for waterproofing purposes were recognized, and extensive laboratory tests were immediately begun to determine the physical properties of concrete and mortar, containing various quantities of oil admixtures.

These tests have now extended over a period of considerably more than two years. Many valuable data have been obtained, through both laboratory and service tests, which demonstrate very definitely the worth of oil-mixed concrete in damp-proof and waterproof structures. The conclusions so far reached may be summarized briefly as follows:

It has been shown that the admixture of oil is not detrimental to the tensile strength of mortar composed of 1 part cement and 3 parts sand, when the oil added does not exceed 10 per cent of the weight of the cement used. The compressive strength of mortar and of concrete suffers slightly with the addition of oil, although when not to exceed 10 per cent of oil is added the decrease in strength is not serious. Concrete mixed with oil requires a period of time from 50 to 100 per cent longer to set hard than does plain concrete, but the increase in strength is nearly as rapid in the oil-mixed material as in the plain concrete.

Concrete and mortar containing oil admixtures are almost perfectly non-absorbent of water, and are therefore excellent materials to use in damp-proof construction. The addition of oil, however, does not appear to increase to any great extent the impermeability of concrete subjected to heavy water pressure, and this method alone will probably not make the concrete proof against the actual percolation of water through the mass. It has been found that strict attention to the details of proportioning, mixing and placing concrete accomplishes more toward making it waterproof or impermeable than the addition of any extraneous material. On the other hand, no amount of care in connection with the preparation of concrete prevents the absorption of water into the mass. The addition of some water-repellent compound appears absolutely necessary to insure this result, and for this purpose laboratory tests have shown these oils to be at least equal to any other substance that has been used. Laboratory tests show that oil-mixed concrete is just as tough and stiff as plain concrete, and, furthermore, its elastic behavior within working limits of stress is identical with that of plain concrete.

The bond between concrete and plain-bar reinforcement is decreased by the use of oil in the concrete, but when deformed bars, wire mesh, or expanded metal is used there is no apparent decrease in the bond.

With the view of determining what effect the addition of oil to cement mortar would have in retarding the action of alkali salts on the cement, a series of experiments was conducted which seemed to indicate that the action of the salt solution is materially retarded by the addition of 5 to 10 per cent of oil to a 1:3 mixture.

SERVICE TESTS.

Observations to date show that no apparent advantage has been gained by the addition of oil for road surface.

Service tests of oil-mixed concrete used as a damp-proofing material have also been made. A vault 112 feet long by 18 feet wide in the United States Treasury Building was constructed in the fall of 1910. The side walls of this vault contain 10 per cent of oil based on the weight of cement in the mixture. The roof was constructed of ordinary reinforced concrete with about 3 inches of 10 per cent oil-mixed concrete placed on top. For months the roof of this vault was subjected to several feet head of water, without showing any signs of leakage. Another vault in the north end of the Treasury, on account of leaking, had never been available for storing anything of value. Oil-mixed concrete was placed on the roof of this vault, and it is perfectly dry at the present time. Numerous floors of the sub-basement of the Treasury Building and in the new Bureau of Engraving and Printing, and a floor in the Office of Public Roads, have been constructed with oil-mixed concrete and have remained entirely free from dampness up to the present time.

Several tanks constructed of oil-mixed concrete in the testing laboratory of the Office of Public Roads have remained absolutely watertight since their completion over a year ago. One of these tanks was made of a mixture of concrete composed of 1 part of cement, 2 parts of sand and 4 parts of stone, mixed with 10 per cent of oil based on the weight of cement in the mixture. It is used for storing concrete test specimens and is 14 feet long by 5 feet wide by 4½ feet deep. The bottom of this tank is 4 inches thick and is deposited on the cement floor of the laboratory. The sides are 6 inches in thickness and are reinforced with one-half inch deformed steel bars. A second tank was built very successfully, merely by plastering oil-mixed Portland cement mortar against one-half inch mesh expanded metal. Although the sides and bottom of this tank are but 1 inch thick, it is absolutely water-tight against about 2 feet of head.

A very interesting experiment showing the non-absorbent and non-permeable character of oil-mixed mortar when subjected to low pressure was made. Four mortar receptacles, 8 inches in outside diameter, 2½ inches high, and with walls and bottom one-half inch in thickness, were immersed in water to a depth of about 2 inches after they had cured in moist air for one week. A mortar mixture of one part of cement to three parts of sand was used. Specimen No. 1, which contained no oil, showed a damp spot on the inside after immersion for about one minute. After one hour's immersion it was damp over the entire inner surface to a height somewhat greater than the level of the water in the dish. This was caused in part by capillarity. Within a few days water had penetrated this receptacle until the level inside was the same as that outside. The remaining three vessels, made of 1:3 mortar and mixed with 5, 10 and 20 per cent of oil, respectively, remained perfectly dry on the inside during immersion for one year.

MATERIALS USED.

As ordinarily made, concrete consists of a mixture of cement, sand, broken stone or gravel, and water. Oil-mixed concrete differs from ordinary concrete only in that oil is an additional ingredient in the mixture. It is important that the materials used in any concrete mixture be of the proper kind and be combined in the correct proportions for the work in hand.

Cement.—By far the best cement for use in oil-mixed concrete is Portland cement, not only because of its more uniform quality, but also because of its greater strength, which permits it to be mixed with a larger percentage of properly proportioned aggregate. For unimportant work it is usually safe to select a brand of cement of well-known reputation and use it without testing, although even for work of an insignificant character it is preferable to test the cement for its soundness or its liability to disintegrate.

A very quick test for soundness may be made by kneading some of the cement with enough water to form a paste of such consistency that it may be molded into a ball without crumbling. This ball, which should be about 1¼ inches in diameter, should be allowed to harden under a moistened cloth for twenty-four hours, after which it should be placed in a pan of cold water, and the water heated to the boiling point. If the cement ball shows no signs of cracking after boiling for three hours, and remains hard and not disintegrated in any way, the indications are strongly in favor of the fitness of the sample.

On work of any importance, the cement should be carefully sampled and tested by a testing laboratory equipped for that purpose.

Sand.—The character of the sand used in a concrete mixture has a marked effect on the strength of the concrete. The sand should be clean and coarse. It is not

*Extracts from *Bulletin* 230, U. S. Dept. of Agriculture, by Logan Waller Page, Director, Office of Public Roads.

advisable to permit more than 5 per cent of silt or clay in the sand, since both of these materials tend to weaken a rich concrete mixture when present in large quantities. The sand grains should be coarse; that is, should be graded in size from 1/32 up to 1/8 or ¼ inch in diameter. Sand graded in size from small to large makes a denser and stronger mortar than sand of uniform size. Should fine sand be the only material available, it will be necessary to use an increased quantity of cement in order to obtain the same strength that would be obtained from the use of a coarser sand.

Stone.—The best rocks for concrete are, in general, the traps and granites, although some varieties of sandstone and limestone give very good results. Gravel which is clean makes an excellent material for use in concrete. The best results are usually obtained with stone graded in size from ¼ inch up to 1½ inches, but for reinforced work a maximum size of 1 inch is preferable. Whenever gravel is used, it should be screened through a ¼ inch mesh screen and the finer particles should be later recombined with the coarser particles in the correct proportions. It is not a wise procedure to mix cement with the gravel as it comes from the bank, since the sand and larger pebbles are generally not proportioned correctly to obtain the densest and strongest concrete.

Water.—The mixing water should be clean and free from all strong acids, alkalies, and vegetable matter.

Specifications for Oil to be Used in Oil-cement Concrete (Subject to revision).—(1) The oil shall be a fluid petroleum product and shall contain no admixture of fatty or vegetable oils.

(2) It shall have a specific gravity not greater than 0.945 at a temperature of 25 deg. Cent.

(3) It shall show a flash point of not less than 150 deg. Cent. by the closed-cup method.

(4) When 240 cubic centimeters of the oil is heated in an Engler viscosimeter to 50 deg. Cent., and maintained at that temperature for at least three minutes, the first 100 cubic centimeters which flows out shall show a specific viscosity of not less than 15 nor more than 30.

(5) When one part of the oil is shaken up with two parts of hundredth normal caustic soda, there shall be no emulsification, and upon allowing the mixture to remain quiet the two components shall rapidly separate in distinct layers.

The general purpose of the above clauses is as follows: Clause 1 eliminates compounded products in which the presence of saponifiable oils would break down the strength of the cement. Clause 5 has a similar purpose in eliminating certain straight petroleum residuals which readily emulsify with alkali, and seriously impair the strength of the mortar to which they are added. Clauses 2, 3, and 4 combine to prevent the use of certain asphaltic oils which prove detrimental to the strength of the concrete, and clause 4, in particular, prescribes an oil of such viscosity as to be readily miscible with the mortar, while still possessing sufficient body to render the structure damp proof.

METHOD OF MAKING.

For most purposes where damp-proofing is required 5 per cent of oil based on the weight of cement in the mixture is all that is necessary. A bag of cement weighs 94 pounds, and consequently, for each bag of cement used in the mixture, 4.7 pounds or about 2½ quarts of oil are required.

Let it be supposed that a batch of concrete requiring two bags of cement is to be mixed in the proportions of one part of cement to two parts of sand to four parts of broken stone or gravel, together with 5 per cent of oil. Four cubic feet of sand are first measured out in a bottomless box 12 inches deep and 2 feet on each side. On the top of the sand is spread the cement and these materials are mixed together until they appear to be of uniform color. Water is then added to the mixture and the mass again mixed to a mortar of mushy consistency. Five quarts of oil are then measured out and added to the mortar, and the mass again turned until there is no trace of oil visible on the surface of the mortar. Particular care should be taken to continue the mixing until the oil is thoroughly incorporated in the mixture. Experience has shown that to insure the very best results the length of time of mixing should be practically double that required when oil is not used. The oil-mixed mortar is then combined with the stone or gravel previously moistened and the mass is again turned until all of the stone is thoroughly coated with the mortar and the mass is uniformly mixed throughout. Should only oil-mixed mortar be desired, the process is similar to that above described except that no stone is added.

In a machine mixer the cement, sand, and water are first mixed to a mortar, when alternate batches of oil and stone are added until the required quantity of oil is mixed, and then the remainder of the stone is added and mixed. When a batch mixer is used, the exact method of procedure should be determined by experiment, owing to the fact that different makes of mixers require slightly different handling to insure best results. A continuous mixer should not be used in oil-cement-concrete work, as with this type the time of mixing can not readily be increased to the extent necessary to insure a uniform distribution of the oil.

MATERIAL REQUIRED FOR ONE CUBIC YARD.

The following table gives the proportions by parts and amounts required of cement, sand, stone, and oil to make a cubic yard of oil-mixed mortar and concrete:

Quantities of Materials Required for One Cubic Yard of Oil-mixed Mortar and Concrete.

Proportions by parts.				Cement (barrels[1]).	Sand (cubic yards).	Stone or gravel (cubic yards)	Oil (gallons[2]).
Cement.	Sand.	Stone or gravel.	Oil (per cent).				
1	......	......	3	8.31	......	......	12.1
1	2	......	5	3.32	0.93	......	8.06
1	3	......	5 10	2.48	1.05	......	6.02 12.04
1	4	......	5 10	1.98	1.11	......	4.8 9.61
1	2	4	5	1.57	0.44	0.88	3.81
1	2½	5	5 10	1.30	0.46	0.92	3.15 6.3
1	3	6	5 10	1.11	0.47	0.94	2.69 5.38

[1] One barrel of cement equals 4 bags.
[2] Oil weighs about 7¾ pound per gallon.

USES.

All of the laboratory and service tests thus far made on oil-mixed mortars and concretes are indicative of a wide future usefulness for these materials, principally in damp-proof construction. There are many types of structures through which the permeation of moisture is ruinous to either the appearance or the efficiency of the construction, or is seriously detrimental to the health of either animal or human life. The efflorescence due to the leaching out and subsequent carbonization of the lime on the surface of a concrete wall might well be prevented by the incorporation of an agent capable of excluding all moisture. Again, the dampness of many cellars, with its danger to health, could have been prevented had the walls and floors been damp-proofed. The following types of structures might be damp-proofed at an exceedingly slight extra expense by the incorporation of a small amount of the proper kind of mineral oil residuum with the mortar or concrete used in construction: Basement floors, basement walls, watering troughs, cisterns, barns, silos, irrigating canals, the concrete base for bituminous concrete and asphalt roadways, concrete blocks, roofs, stucco, and numerous important engineering constructions.

(To be concluded.)

Paper from Grapevines

To publishers and to readers alike—and that includes the civilized world—the rapid advance in the cost of white paper of recent years is a matter of grave moment. This is largely due, of course, to the wasteful and improvident deforestation which has been going on, particularly in this country, though the enormous increase in the use of celluloid and other products of cellulose, including artificial silk and gun-cotton, must bear a part of the responsibility. In France, owing to the war, the situation is particularly acute, since the wooded districts in the northern and eastern section of the country have become the scene of conflict. For this reason there has been a determined effort on the part of French scientists to find practical substitutes for wood pulp.

As far back as 1909 Prof. Chaptal of Montpellier, collaborating with the Agricultural Syndicate of Léziguan, had elaborated a process for making paper pulp from vine cuttings. This consists of "breaking" the vines in a suitable machine, treating them with a warm mixture of dilute hydrochloric and nitric acids, boiling the resultant mass of pulp and then passing it through a sieve. The yield of cellulose is about 30 per cent. This is excellent, since the yield of poplar wood is but 35 per cent.

Recently this subject has been made the theme of further investigation, notably at the professional School of Paper Making at Grenoble. It has been proved here that paper suitable for printing, for lithography, and for photographing can be made from the vines, provided a certain proportion of pine wood-pulp treated with bisulphite is added to the vine-pulp. Unfortunately the physical and chemical operations involved are costly. In short, to turn the crude material into the finished product can be done at a cost of 15 francs ($3.00) per quintal, while the market price obtainable is but 13 francs ($2.60) per quintal. This excessive cost is due to the fact that besides the bleaching process it is necessary to remove from the crude pulp the knots and two-year wood not transformed by the acids.

It is obvious, however, that in lower-grade paper-pulp, such as can be used for wrapping paper, cardboard, boxes, etc., the cost of refinement can be saved. The crude pulp for pasteboard can be made for 5 francs ($1.20) per quintal. Moreover, there are two by-products which possess a commercial value; the wash-waters, which are very rich in tannin, and the residuum from these, which can be used for fertilizer.

According to *La Nature* (Paris) from which we take these facts, even if the vine-pulp cannot be used alone for wrapping paper (16 to 18 francs, $3.20 to $3.60, per quintal) or for pasteboard (12 to 14 francs, $2.40 to $2.80, per quintal) it can be used to form a mixture with wood-pulp and rag-pulp at a cost of 9 francs, ($1.80) per quintal, thus leaving a margin of profit of 4 francs ($0.80) per quintal.

This new industry has already been organized, and in the neighborhood of Beziers and Narbonne there are already fifteen to twenty factories capable of turning out 4 tons of pulp every 24 hours, using the vines furnished within a radius of 5 kilometers from the works.

Prof. Chaptal reckons that the ligneous mass which the vines of France can provide will equal that coming from the normal use of the red pine cut in a mature forest of 600,000 hectares extent during a period of 60 years.

The practical results thus obtained ought to interest paper manufacturers in various regions of the United States, where similar raw material can be obtained.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, JANUARY 29, 1916.

Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer; all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) . . . . " 3.00

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